



Commission on Accreditation of Allied Health Education Programs

Standards and Guidelines for the Accreditation of Educational Programs in Neurodiagnostic Technology

Essentials/Standards initially adopted in 1973; revised in 1980, 1987, 1994, 2002, 2008, and 2017 by
the:

American Academy of Neurology
American Clinical Neurophysiology Society
American Society of Neurophysiologic Monitoring
ASET – The Neurodiagnostic Society
Committee on Accreditation for Education in Neurodiagnostic Technology
and
Commission on Accreditation of Allied Health Education Programs

The Commission on Accreditation of Allied Health Education Programs (CAAHEP) accredits programs upon the recommendation of the Committee on Accreditation for Education in Neurodiagnostic Technology (CoA-NDT).

These accreditation **Standards and Guidelines** are the minimum standards of quality used in accrediting programs that prepare individuals to enter the Neurodiagnostic Technology (NDT) profession with or without one or more of the following add-ons: Evoked Potentials (EP); Polysomnography (PSG); Nerve Conduction Studies (NCS); Long Term Monitoring (LTM); and Intraoperative Neuromonitoring (IONM). Standards are the minimum requirements to which an accredited program is held accountable. Guidelines are descriptions, examples, or recommendations that elaborate on the Standards. Guidelines are not required, but can assist with interpretation of the Standards.

Standards are printed in regular typeface in outline form. *Guidelines* are printed in italic typeface in narrative form.

Preamble

The Commission on Accreditation of Allied Health Education Programs (CAAHEP), American Academy of Neurology (AAN), American Clinical Neurophysiology Society (ACNS), ASET – The Neurodiagnostic Society, American Society of Neurophysiologic Monitoring (ASNM) and Committee on Accreditation for Education in Neurodiagnostic Technology (CoA-NDT) cooperate to establish, maintain, and promote appropriate standards of quality for educational programs in neurodiagnostic technology with or without one or more of the following add-ons: Evoked Potentials (EP); Polysomnography (PSG); Nerve Conduction Studies (NCS); Long Term Monitoring (LTM); and Intraoperative Neuromonitoring (IONM), and to provide recognition for educational programs that meet or exceed the minimum standards outlined in these accreditation **Standards and Guidelines**. Lists of accredited programs are published for the information of students, employers, educational institutions and agencies, and the public.

These **Standards and Guidelines** are to be used for the development, evaluation, and self-analysis of a NDT program with or without one or more of the following add-ons: EP, PSG, NCS, LTM and IONM. On-site review teams assist in the evaluation of a program's relative compliance with the accreditation Standards.

Profession Description

Neurodiagnostics is the allied health care profession that records, monitors, and analyzes nervous system function to promote the effective treatment of pathologic conditions. Technologists record electrical activity arising from the brain, spinal cord, peripheral nerves, somatosensory or motor nerve systems using a variety of techniques and instruments. Technologists prepare data and documentation for interpretation by a physician. Considerable individual initiative, reasoning skill, and sound judgment are all expected of the neurodiagnostic technologist. The most common neurodiagnostic procedures are Electroencephalogram (EEG), Evoked Potential (EP), Polysomnogram (PSG), Nerve Conduction Study (NCS), Long Term Monitoring (LTM), and Intraoperative Neuromonitoring (IONM).

Neurodiagnostic technologists: are credentialed; have met a minimum education level and related educational and performance standards; meet continuing education requirements; perform within a code of ethics and defined scope of practice; are recognized by physicians, employers, the public, governmental agencies, payers and other health care professionals; have a national society whose activities include lobbying for the profession; and contribute to the advancement of knowledge in neuroscience.

I. Sponsorship

A. Sponsoring Institution

A sponsoring institution must be at least one of the following, and must either award credit for the program or have an articulation agreement with an accredited post-secondary institution:

1. A post-secondary institution accredited by an institutional accrediting agency that is recognized by the U.S. Department of Education, and authorized under applicable law or other acceptable authority to provide a post-secondary program, which awards a minimum of a certificate/diploma at the completion of the program.
2. A hospital, clinic or medical center that is institutionally accredited and authorized under applicable law or other acceptable authority to provide healthcare, which awards a minimum of a certificate/diploma at the completion of the program.
3. A branch of the United States Armed Forces or other Federal agency, which awards a minimum of a certificate/diploma at the completion of the program.

Sponsoring institutions should develop a curriculum that is consistent with the award of an associate's degree or higher at the completion of the program.

B. Consortium Sponsor

1. A consortium sponsor is an entity consisting of two or more members that exists for the purpose of operating an educational program. In such instances, at least one of the members of the consortium must meet the requirements of a sponsoring educational institution as described in I.A.
2. The responsibilities of each member of the consortium must be clearly documented in a formal affiliation agreement or memorandum of understanding, which includes governance and lines of authority.

C. Responsibilities of Sponsor

The Sponsor must assure that the provisions of these **Standards and Guidelines** are met.

II. Program Goals

A. Program Goals and Outcomes

There must be a written statement of the program's goals and learning domains consistent with and responsive to the demonstrated needs and expectations of the various communities of interest served by the educational program. The communities of interest that are served by the program must include, but are not limited to, students, graduates, faculty, sponsor administration, employers, physicians, and the public.

Program-specific statements of goals and learning domains provide the basis for program planning, implementation, and evaluation. Such goals and learning domains must be compatible with the mission of the sponsoring institution(s), the expectations of the communities of interest, and nationally accepted standards of roles and functions. Goals and learning domains are based upon the substantiated needs of health care providers and employers, and the educational needs of the students served by the educational program.

B. Appropriateness of Goals and Learning Domains

The program must regularly assess its goals and learning domains. Program personnel must identify and respond to changes in the needs and/or expectations of its communities of interest.

An advisory committee, which is representative of at least each of the communities of interest named in these **Standards**, must be designated and charged with the responsibility of meeting at least annually, to assist program and sponsor personnel in formulating and periodically revising appropriate goals and learning domains, monitoring needs and expectations, and ensuring program responsiveness to change.

Advisory committee meetings may include participation by synchronous electronic means.

C. Minimum Expectations

The program must have one of the following goals defining minimum expectations:

1. "To prepare competent entry-level neurodiagnostic technologists in the cognitive (knowledge), psychomotor (skills), and affective (behavior) learning domains."
2. "To prepare competent entry-level neurodiagnostic technologists in the cognitive (knowledge), psychomotor (skills), and affective (behavior) learning domains with additional expertise in each of the following add-ons that the program offers: Evoked Potentials (EP); Polysomnography (PSG); Nerve Conduction Studies (NCS); Long Term Monitoring (LTM); and/or Intraoperative Neuromonitoring (IONM)."

Programs adopting educational goals beyond entry-level competence must clearly delineate this intent and provide evidence that all students have achieved the basic competencies prior to entry into the field.

Nothing in this Standard restricts programs from formulating goals beyond entry-level competence.

III. Resources

A. Type and Amount

Program resources must be sufficient to ensure the achievement of the program's goals and outcomes. Resources must include, but are not limited to: faculty; clerical and support staff; curriculum; finances; offices; classroom, laboratory, and, ancillary student facilities; clinical affiliates; equipment; supplies; computer resources; instructional reference materials; and faculty/staff continuing education.

Classrooms and laboratories should be able to accommodate the assigned number of students and should be well lit, ventilated, furnished, and equipped, and available at times commensurate with the needs of the program and its students.

Learning resources should be accessible to students outside of required attendance hours (e.g., evenings and weekends). Instructional plans should promote student utilization of these resources.

Examples of computer resources are computer-assisted instruction materials, patient care simulations, and access to internet resources.

B. Personnel

The sponsor must appoint sufficient faculty and staff with the necessary qualifications to perform the functions identified in documented job descriptions and to achieve the program's stated goals and outcomes.

1. Program Director

a. Responsibilities

The program director must be responsible for all aspects of the program, including but not limited to the:

- 1) administration, organization, and supervision of the educational program, including ensuring physician interaction with and instruction of students;
- 2) continuous quality review and improvement of the educational program;
- 3) long range planning and ongoing development of the program; and,
- 4) outcomes of the program and appropriate systems to ensure the effectiveness of the program.

b. Qualifications

The program director must:

- 1) hold at least one active certification or registration within the neurodiagnostic profession;
- 2) have a minimum of a Bachelor's Degree; and
- 3) demonstrate clinical and teaching experience.

The program director should have a minimum of 5 years clinical and/or teaching experience; and should possess expertise and experience in leadership, organization, and teaching.

2. Curriculum Coordinator(s)

The sponsor must appoint a curriculum coordinator(s) with the R EEG T credential when either the program director does not hold the R EEG T credential; or with the appropriate add-on specific credential(s) when the program offers one or more add-ons for which the program director does not hold the appropriate add-on specific credential(s).

a. Responsibilities

The curriculum coordinator(s) report(s) to the program director, and must be responsible for the coordination of the add-on(s) for which the program director does not hold the appropriate credential.

b. Qualifications

The curriculum coordinator(s) must:

- 1) be an appointed faculty member or institutional equivalent;
- 2) hold the appropriate credential(s) specific to the add-on content

- 3) hold academic credentials at least equivalent to the academic credential that is offered by the program; and,
- 4) demonstrate clinical and teaching experience.

The curriculum coordinator for an IONM add-on must:

- 1) be an appointed faculty member or institutional equivalent;
- 2) hold the appropriate credential(s) specific to the add-on content;
- 3) hold academic credentials at least equivalent to the academic credential that is offered in the program;
- 4) have a minimum of three (3) years clinical experience in IONM; and
- 5) have a minimum of two (2) years teaching experience in a related field.

Teaching experience in related fields should include teaching in clinical practice areas in neurodiagnostic technology.

3. Medical Director

a. Responsibilities

The medical director of the program, including for any add-ons that are offered by the program, must:

- 1) provide the input necessary to ensure that the medical components of the curriculum, both the didactic and supervised clinical practice, meet current standards of medical practice; and
- 2) promote the cooperation and support of practicing physicians for interaction with and instruction of students.

b. Qualifications

The medical director must be a physician licensed to practice medicine in the country in which students are enrolled, with appropriate credentials and experience in clinical neurophysiology.

4. Associate Medical Director(s)

One or more associate medical director(s) must be appointed by the sponsor when either the medical director delegates specified responsibilities to another physician or when the medical director does not hold professional credentials appropriate to the add-ons that are offered by the program.

a. Responsibilities

- 1) Fulfill responsibilities delegated by the program medical director.
- 2) provide the input necessary to ensure that the medical components of the curriculum, both the didactic and supervised clinical practice, that are delegated by the program medical director meet current standards of medical practice; and
- 3) promote the cooperation and support of practicing physicians for interaction with, and instruction of, students.

b. Qualifications

The associate medical director(s) must be a physician licensed to practice medicine in the country in which students are enrolled, with appropriate credentials and experience for the duties delegated by the medical director.

In addition, the associate medical director for an IONM add-on must:

- 1) be a neurologist or neurophysiologist licensed to practice in the United States;
- 2) be board certified in IONM or meet the IONM experience required for completion of a clinical neurology fellowship program; and
- 3) demonstrate competence in the practice of IONM; and,
- 4) have a minimum of five (5) years of current experience in IONM.

Competence may be demonstrated by evidence of participating in recent surgeries, hospital privileges for neuromonitoring, case logs and/or types of cases monitored within the last five years, authorship of scientific publications in professional IONM literature, participation in professional IONM meetings, and preparation and/or presentation of IONM workshops or lectures at professional meetings.

5. Faculty and Clinical Instructional Staff

a. Responsibilities

In classrooms, laboratories, and all clinical facilities where a student is assigned, there must be a qualified individual(s) clearly designated as a liaison(s) to the program to provide instruction, supervision, and timely assessments of the student's progress in meeting program requirements.

b. Qualifications

Instructors must be knowledgeable in subject matter by virtue of appropriate credential(s), training, and experience in the designated content area.

C. Curriculum

The curriculum must ensure the achievement of program goals and learning domains. Instruction must be an appropriate sequence of classroom, laboratory, and clinical activities. Instruction must be based on clearly written course syllabi that include course description, course objectives, methods of evaluation, topic outline, and competencies required for graduation. The curriculum must include competencies in emergency preparedness consistent with the profession.

1. CoA-NDT Approved Curriculum

The program must demonstrate by comparison that the curriculum offered meets or exceeds the "CoA-NDT Graduate Competencies" listed in Appendix B of these **Standards and Guidelines**.

The following general education content should either be completed prior to entry into the technical phase of the program or incorporated into the curriculum plan; basic algebra; written and oral communication; social/behavioral sciences; computer science; and, critical thinking skills.

2. Physician Interaction

The program must demonstrate physician interaction with students through instruction that contributes to achievement of the program's goals and outcomes.

The purpose of the instructional interaction and input is both to convey knowledge and perspective, and to develop effective communication skills between physicians and students.

D. Resource Assessment

The program must, at least annually, assess the appropriateness and effectiveness of the resources described in these **Standards**. The results of resource assessment must be the basis for ongoing planning and appropriate change. An action plan must be developed when deficiencies are identified in the program resources. Implementation of the action plan must be documented and results measured by ongoing resource assessment.

Records of implementation of the action plan should be maintained and should minimally include the purpose, measurements, results, analyses, and follow-up for each resource being assessed.

Other dimensions of the program may merit assessment, such as appropriateness of admission criteria and process, curriculum design, and productivity of the Advisory Committee.

IV. Student and Graduate Evaluation/Assessment

A. Student Evaluation

1. Frequency and purpose

Evaluation of students must be conducted on a recurrent basis and with sufficient frequency to provide both the students and program faculty with valid and timely indications of the students' progress toward and achievement of the competencies and learning domains stated in the curriculum.

2. Documentation

Records of student evaluations must be maintained in sufficient detail to document learning progress and achievements.

Documentation should include, but need not be limited to appropriate written, practical and oral evaluations of student achievement that are based on all components of the Neurodiagnostic Technology curriculum.

B. Outcomes

1. Outcomes Assessment

The program must periodically assess its effectiveness in achieving its stated goals and learning domains. The results of this evaluation must be reflected in the review and timely revision of the program.

Outcomes assessments must include, but are not limited to: national credentialing examination(s) performance, programmatic retention/attrition, graduate satisfaction, employer satisfaction, job (positive) placement, and programmatic summative measures. The program must meet the outcomes assessment thresholds.

"Positive placement" means that the graduate is employed full or part-time in the profession or in a related field; and/or continuing his/her education; and/or serving in the military. A related field is one in which the individual is using cognitive, psychomotor, and affective competencies acquired in the educational program.

Programmatic summative assessment measures should include tools such as comprehensive final examinations, terminal competency assessment, or student performance in a capstone course.

2. Outcomes Reporting

The program must periodically submit to the CoA-NDT the program goal(s), learning domains, evaluation systems (including type, cut score, and appropriateness), outcomes, its analysis of the outcomes and an appropriate action plan based on the analysis.

Programs not meeting the established thresholds must begin a dialogue with the CoA-NDT to develop an appropriate plan of action to respond to the identified shortcomings.

V. Fair Practices

A. Publications and Disclosure

1. Announcements, catalogs, publications, and advertising must accurately reflect the program offered.
2. At least the following must be made known to all applicants and students: the sponsor's institutional and programmatic accreditation status as well as the name, mailing address, web site address and phone number of the accrediting agencies; admissions policies and practices,

including technical standards (when used); policies on advanced placement, transfer of credits, and credits for experiential learning; number of credits required for completion of the program; tuition/fees and other costs required to complete the program; policies and processes for withdrawal and for refunds of tuition/fees.

3. At least the following must be made known to all students: academic calendar; student grievance procedure; criteria for successful completion of each segment of the curriculum and for graduation; and policies and processes by which students may perform clinical work while enrolled in the program.
4. The sponsor must maintain, and make available to the public, current and consistent summary information about student/graduate achievement that includes the results of one or more of the outcomes assessments required in these **Standards**.

The sponsor should develop a suitable means of communicating to the communities of interest the achievement of students/graduates (e.g. through a website or electronic or printed documents).

B. Lawful and Non-discriminatory Practices

All activities associated with the program, including student and faculty recruitment, student admission, and faculty employment practices, must be non-discriminatory and in accord with federal and state statutes, rules, and regulations. There must be a faculty grievance procedure made known to all paid faculty.

C. Safeguards

The health and safety of patients, students, faculty, and other participants associated with the educational activities of the students must be adequately safeguarded.

All activities required in the program must be educational and students must not be substituted for staff.

D. Student Records

Satisfactory records must be maintained for student admission, advisement, counseling, and evaluation. Grades and credits for courses must be recorded on the student transcript and permanently maintained by the sponsor in a safe and accessible location.

E. Substantive Changes

The sponsor must report substantive change(s) as described in Appendix A to CAAHEP/CoA-NDT in a timely manner. Additional substantive changes to be reported to the CoA-NDT within the time limits prescribed include:

1. changes in the curriculum that result in a change of 10% or more of the program credits;
2. converting a seated program to a distance program, or a distance program to a seated program;
3. changes in the degree or certificate awarded;
4. changes in ownership or control of the sponsoring institution;
5. changes in the organizational structure or mission of the college or hospital, including changes in other departments (e.g., general education) that have an impact on the program.

F. Agreements

There must be a formal affiliation agreement or memorandum of understanding between the sponsor and all other entities that participate in the education of the students describing the relationship, roles, and responsibilities of the sponsor and that entity.

APPENDIX A

Application, Maintenance and Administration of Accreditation

A. Program and Sponsor Responsibilities

1. Applying for Initial Accreditation

- a. The chief executive officer or an officially designated representative of the sponsor completes a "Request for Accreditation Services" form.

The "Request for Accreditation Services" form can be obtained from the CAAHEP website at <https://www.caahep.org/program-directors/request-for-accreditation-services1>.

Note: There is **no** CAAHEP fee when applying for accreditation services; however, individual committees on accreditation may have an application fee.

- b. The program undergoes a comprehensive review, which includes a written self-study report and an on-site review.

The self-study instructions and report form are available from the Committee on Accreditation for Education in Neurodiagnostic Technology (CoA-NDT). The on-site review will be scheduled in cooperation with the program and CoA-NDT once the self-study report has been completed, submitted, and accepted by the CoA-NDT.

2. Applying for Continuing Accreditation

- a. Upon written notice from the CoA-NDT, the chief executive officer or an officially designated representative of the sponsor completes a "Request for Accreditation Services" form.

The "Request for Accreditation Services" form can be obtained from the CAAHEP website at <https://www.caahep.org/program-directors/request-for-accreditation-services1>.

- b. The program may undergo a comprehensive review in accordance with the policies and procedures of the CoA-NDT.

If it is determined that there were significant concerns with the conduct of the on-site review, the sponsor may request a second site visit with a different team.

After the on-site review team submits a report of its findings, the sponsor is provided the opportunity to comment in writing and to correct factual errors prior to the CoA-NDT forwarding a recommendation to CAAHEP.

3. Administrative Requirements for Maintaining Accreditation

- a. The program must inform the CoA-NDT and CAAHEP within a reasonable period of time (as defined by the committee on accreditation and CAAHEP policies) of changes in chief executive officer, dean of health professions or equivalent position, and required program personnel (Refer to Standard III.B.).
- b. The sponsor must inform CAAHEP and the CoA-NDT of its intent to transfer program sponsorship. To begin the process for a Transfer of Sponsorship, the current sponsor must submit a letter (signed by the CEO or designated individual) to CAAHEP and the CoA-NDT that it is relinquishing its sponsorship of the program. Additionally, the new sponsor must submit a "Request for Transfer of Sponsorship Services" form. The CoA-NDT has the discretion of requesting a new self-study report with or without an on-site review. Applying for a transfer of sponsorship does not guarantee that the transfer of accreditation will be granted.
- c. The sponsor must promptly inform CAAHEP and the CoA-NDT of any adverse decision affecting its accreditation by recognized institutional accrediting agencies and/or state agencies (or their equivalent).
- d. Comprehensive reviews are scheduled by the CoA-NDT in accordance with its policies and procedures. The time between comprehensive reviews is determined by the CoA-NDT and based on the program's on-going compliance with the Standards, however, all programs must undergo a comprehensive review at least once every ten years.
- e. The program and the sponsor must pay CoA-NDT and CAAHEP fees within a reasonable period of time, as determined by the CoA-NDT and CAAHEP respectively.
- f. The sponsor must file all reports in a timely manner (self-study report, progress reports, probation reports, annual reports, etc.) in accordance with CoA-NDT policy.
- g. The sponsor must agree to a reasonable on-site review date that provides sufficient time for CAAHEP to act on a CoA-NDT accreditation recommendation prior to the "next comprehensive review" period, which was designated by CAAHEP at the time of its last accreditation action, or a reasonable date otherwise designated by the CoA-NDT.

Failure to meet any of the aforementioned administrative requirements may lead to administrative probation and ultimately to the withdrawal of accreditation. CAAHEP will immediately rescind administrative probation once all administrative deficiencies have been rectified.

4. Voluntary Withdrawal of a CAAHEP- Accredited Program

Notification of voluntary withdrawal of accreditation from CAAHEP must be made by the Chief Executive Officer or an officially designated representative of the sponsor by writing to CAAHEP indicating: the desired effective date of the voluntary withdrawal, and the location where all records will be kept for students who have completed the program.

5. Requesting Inactive Status of a CAAHEP- Accredited Program

Inactive status for any accredited program may be requested from CAAHEP at any time by the Chief Executive Officer or an officially designated representative of the sponsor writing to CAAHEP indicating the desired date to become inactive. No students can be enrolled or matriculated in the program at any time during the time period in which the program is on inactive status. The maximum period for inactive status is two years. The sponsor must continue to pay all required fees to the CoA-NDT and CAAHEP to maintain its accreditation status.

To reactivate the program the Chief Executive Officer or an officially designated representative of the sponsor must provide notice of its intent to do so in writing to both CAAHEP and the CoA-NDT. The sponsor will be notified by the CoA-NDT of additional requirements, if any, that must be met to restore active status.

If the sponsor has not notified CAAHEP of its intent to re-activate a program by the end of the two-year period, CAAHEP will consider this a “Voluntary Withdrawal of Accreditation.”

B. CAAHEP and Committee on Accreditation Responsibilities – Accreditation Recommendation Process

1. After a program has had the opportunity to comment in writing and to correct factual errors on the on-site review report, the CoA-NDT forwards a recommendation to the CAAHEP Board of Directors. The recommendation may be for initial accreditation, continuing accreditation, or probationary accreditation, or to withhold or withdraw accreditation.

The decision of the CAAHEP Board of Directors is provided in writing to the sponsor immediately following the CAAHEP meeting at which the program was reviewed and voted upon.

2. Before the CoA-NDT forwards a recommendation to CAAHEP that a program be placed on probationary accreditation, the sponsor must have the opportunity to request reconsideration of that recommendation or to request voluntary withdrawal of accreditation. The CoA-NDT reconsideration of a recommendation for probationary accreditation must be based on conditions existing both when the committee arrived at its recommendation as well as on subsequent documented evidence of corrected deficiencies provided by the sponsor.

The CAAHEP Board of Directors’ decision to confer probationary accreditation is not subject to appeal.

3. Before the CoA-NDT forwards a recommendation to CAAHEP that a program’s accreditation be withdrawn or that accreditation be withheld, the sponsor must have the opportunity to request reconsideration of the recommendation, or to request voluntary withdrawal of accreditation or withdrawal of the accreditation application, whichever is applicable. The CoA-NDT reconsideration of a recommendation of withdraw or withhold accreditation must be based on conditions existing both when the CoA-NDT arrived at its recommendation as well as on subsequent documented evidence of corrected deficiencies provided by the sponsor.

The CAAHEP Board of Directors’ decision to withdraw or withhold accreditation may be appealed. A copy of the CAAHEP “Appeal of Adverse Accreditation Actions” is enclosed with the CAAHEP letter notifying the sponsor of either of these actions.

At the completion of due process, when accreditation is withheld or withdrawn, the sponsor’s Chief Executive Officer is provided with a statement of each deficiency. Programs are eligible to re-apply for accreditation once the sponsor believes that the program is in compliance with the accreditation Standards.

Note: Any student who completes a program that was accredited by CAAHEP at any time during his/her matriculation is deemed by CAAHEP to be a graduate of a CAAHEP-accredited program.

APPENDIX B

NEURODIAGNOSTIC TECHNOLOGY PROGRAM GRADUATE COMPETENCIES AND GRADUATE COMPETENCIES FOR (OPTIONAL) CURRICULUM ADD-ONS

INTRODUCTION: Appendix B contains six groups of graduate competencies.

- Group 1: Graduate competencies for all neurodiagnostic technology programs {Electroencephalography (EEG)}, which also must include the introductory competencies for Evoked Potential Studies (EP), Polysomnography Studies (PSG), Nerve Conduction Studies (NCS), Long Term Monitoring (LTM), and Intraoperative Neurophysiological Monitoring (IONM)
- Group 2: Graduate competencies for programs that choose to add-on the optional Evoked Potential Studies (EP) curriculum content to their neurodiagnostic technology program content.
- Group 3: Graduate competencies for programs that choose to add-on the optional Polysomnography Studies (PSG) curriculum content to their neurodiagnostic technology program content.
- Group 4: Graduate competencies for programs that choose to add-on the optional Nerve Conduction Studies (NCS) curriculum content to their neurodiagnostic technology program content.
- Group 5: Graduate competencies for programs that choose to add-on the optional Long Term Monitoring curriculum content to their neurodiagnostic technology program content.
- Group 6: Graduate competencies for programs that choose to add-on the optional Intraoperative Neurophysiological Monitoring (IONM) curriculum content to their neurodiagnostic technology program content.

GROUP 1 (required of all programs): Neurodiagnostic Technology

The following are Graduate Competencies for performing Electroencephalography (EEG) and additional neurodiagnostic procedures, including introductory competencies for Evoked Potential Studies (EP), Polysomnography Studies (PSG), Nerve Conduction Studies (NCS), Long Term Monitoring (LTM), and Intraoperative Neurophysiological Monitoring (IONM).

a. ELECTROENCEPHALOGRAM (EEG)

Entry-level competency is evidenced by a graduate's knowledge and ability in the following areas:

1) Providing a safe recording environment by:

- a) verifying the identity of each patient according to the most recent Joint Commission Standards;
- b) cleaning and disinfecting electrodes after each procedure;
- c) following Standard Precautions and Transmission-Based Precautions for infection control;
- d) attending to the patient needs appropriately;
- e) recognizing/responding to life-threatening situations;
- f) obtaining and maintaining valid CPR certification;
- g) following established laboratory protocols for sedation;
- h) complying with lab protocols for emergency and disaster situations;
- i) complying with hazardous material handling procedures;
- j) maintaining instrument/equipment in good working order;
- k) evaluating each testing situation;
- l) taking appropriate precautions to ensure electrical safety, including reporting signs of worn or frayed cables; and,
- m) ensuring that the laboratory or testing site adheres to appropriate regulatory and legal standards.

2) Establishing and maintaining a professional, caring rapport with the patient and the patient's family by:

- a) using personal communication skills to achieve patient relaxation/cooperation;
- b) explaining at an age appropriate level all test procedures including activation procedures;
- c) explaining the electrode application method (e.g., paste, collodion);

- d) interacting at all times on a level appropriate to patient's age and mental capacity as well as interacting with parents, guardians and other caretakers;
 - e) maintaining respect and patient confidentiality;
 - f) adhering strictly to HIPPA and hospital guidelines regarding patient confidentiality; and,
 - g) demonstrating appropriate ethical professional behaviors.
- 3) **Determining the patient's physical, mental and emotional condition by:**
- a) assessing the patient's mental age, mental state, and comprehension level;
 - b) noting the patient's overall physical condition;
 - c) recognizing and using appropriate method of electrode application;
 - d) ascertaining the patient's capacity to cooperate with activation procedures;
 - e) deciding if hyperventilation is contraindicated;
 - f) accommodating for disabilities or special needs;
 - g) evaluating the need for additional physiological monitors;
 - h) documenting unusual or inappropriate behavior suggestive of seizure or other event; and,
 - i) examining the possible need for restraints or emergency intervention.
- 4) **Preparing a basic data form that includes:**
- a) obtaining patient information (e.g., name, age, ID number, doctor);
 - b) documenting time, date, and graduate's name or initials;
 - c) noting pertinent patient history and familial medical history;
 - d) listing current medications/sedation and time of last dosage;
 - e) noting time of last meal, handedness and sleep;
 - f) noting time, date, aura, and circumstances of first and last seizure or symptoms;
 - g) assessing and documenting frequency, duration and symptoms of event/seizures;
 - h) specifying the patient's mental, behavioral, and consciousness states;
 - i) illustrating skull defects or anomalies (if any);
 - j) documenting any alteration from laboratory procedure and protocol; and,
 - k) illustrating any modifications in electrode placement.
- 5) **Applying electrodes by following a method that includes:**
- a) measuring and marking the head using the 10/20 measurement system;
 - b) adjusting electrode placement for anatomical defects or anomalies and documenting appropriately;
 - c) prepping patient's scalp prior to electrode application;
 - d) applying electrodes with paste or with collodion/electrolyte or other materials per protocol; and,
 - e) verifying electrode impedances are balanced and consistent with nationally accepted NDT guidelines.
- 6) **Demonstrating knowledge of EEG recording technology by:**
- a) accurately applying appropriate filter and sensitivity settings and making adjustments;
 - b) performing instrument calibration;
 - c) justifying amplifier processing as it relates to digital systems;
 - d) reviewing calibration results according to specified system and ensuring calibration results are acceptable to proceed with recording; and,
 - e) correcting or reporting deviations as appropriate.
- 7) **Obtaining a standard EEG that includes:**
- a) at least 20 minutes of technically acceptable recording (120 pages);
 - b) eye opening and closing to check effects of stimuli on EEG;
 - c) hyperventilation for a minimum of 3 minutes where appropriate (5 minutes in absence);
 - d) performing photic stimulation at frequencies appropriate for history and reactivity;
 - e) determining need for mental stimulation/assessment procedures;
 - f) recording at least one check of electrode impedance;
 - g) recording natural drowsiness and sleep, if possible;
 - h) noting of montage, filters, paper speed, & sensitivity setting changes; and,
 - i) documenting observed behavior, clinical seizure manifestations, etc.

- 8) **Customizing the recording procedure by:**
 - a) evaluating reason for referral, history, and observed waveforms;
 - b) utilizing techniques to bring out or enhance clinical symptoms;
 - c) selecting montages appropriate for abnormalities seen and/or expected;
 - d) selecting appropriate instrument settings;
 - e) encouraging drowsiness and sleep;
 - f) applying additional electrodes to localize abnormal activity;
 - g) monitoring respiration if appropriate; and,
 - h) monitoring ECG rhythms for abnormality.
- 9) **Following appropriate technical criteria when recording:**
 - a) electrocerebral inactivity (brain death);
 - b) neonatal EEG;
 - c) pediatric EEG
 - d) in intensive care or cardiac units; and,
 - e) in surgical areas or operating rooms.
- 10) **Differentiating artifacts from cerebral waveforms by:**
 - a) recognizing possible artifactual waveforms;
 - b) documenting (on the recording) patient movements;
 - c) applying/recording leads for eye potentials or other physiological potentials (e.g., respiration, EKG, EMG);
 - d) replacing electrodes exhibiting questionable activity or contact; and,
 - e) troubleshooting for possible electrical interference.
- 11) **Completing the EEG recording by:**
 - a) removing electrode paste/glue from the patient's scalp and hair using safety precautions;
 - b) describing clinically significant behavior witnessed while in the presence of the patient;
 - c) documenting sedation used, dosage, and effects (if applicable);
 - d) reviewing EEG for appropriate documentation of amplifier settings and montage changes; and
 - e) storing information on appropriate media.
- 12) **Demonstrating knowledge of EEG clinical correlations by:**
 - a) explaining functional neuroanatomy and neurophysiology;
 - b) describing medication effects on the EEG background and waveforms;
 - c) recognizing and using medical terminology and accepted abbreviations;
 - d) defining signs and symptoms for adult neurological disorders;
 - e) defining signs and symptoms for pediatric neurological disorders;
 - f) characterizing seizure manifestations and classifications; and,
 - g) identifying psychiatric and psychological disorders.
- 13) **Describing the benefit of future ongoing professional development for continuing competence post-graduation through the:**
 - a) review of neurodiagnostic procedures with the interpreting physician on a regular basis; and,
 - b) acquisition of continuing education units (CEU).
- 14) **Applying the principles of electronics and mathematics of recording EEGs by accurately:**
 - a) describing how differential amplifiers work;
 - b) computing voltage and frequency of waveforms;
 - c) calculating the duration of waveforms;
 - d) illustrating the polarity of the waveforms;
 - e) defining impedance; and,
 - f) describing analog to digital conversion.
- 15) **Demonstrating the appropriate use of the:**
 - a) 60 Hertz filter;
 - b) filter settings;

- c) sensitivity settings; and,
- d) paper speed or equivalent.

16) Explaining the:

- a) similarities/differences of referential and bipolar montages;
- b) effect of digital filters and waveform displays;
- c) effect of electrode types and electrode material composition; and,
- d) effect of malfunctioning equipment.

17) Accurately recognizing:

- a) normal/normal variant awake and asleep patterns for each age range;
- b) abnormal awake and asleep patterns for each age range;
- c) EEG patterns for levels of consciousness; and,
- d) clinical seizure patterns.

b. INTRODUCTORY EVOKED POTENTIAL STUDIES (EP)

Competency at the introductory level is evidenced by a graduate's knowledge and ability in the following areas:

- 1) explaining common indications for auditory, visual, and somatosensory evoked potentials;
- 2) defining the anatomy, physiology, and pathology of selected sensory organs, nerves, and nerve pathways;
- 3) explaining the generators of evoked potentials;
- 4) stating the principles of stimulation and accurate placement of recording electrodes;
- 5) measuring waveforms and distances used in evoked potential studies;
- 6) reporting criteria that may cause significant changes occurring during evoked potential recordings;
- 7) specifying clinical correlations of evoked potential abnormalities;
- 8) defining the concepts of near field and far field potentials;
- 9) identifying artifacts encountered during evoked potential studies and basic techniques for troubleshooting; and,
- 10) explaining concepts of amplitude, latency, and interpeak latency measurements.

c. INTRODUCTORY POLYSOMNOGRAPHY STUDIES (PSG)

Competency at the introductory level is evidenced by a graduate's knowledge and ability in the following areas:

- 1) accurately recognizing all sleep stages;
- 2) accurately explaining (verbal or in writing) the indications for monitoring PSG;
- 3) initiating a technically adequate PSG by:
 - a) discussing the electrode selection and montages used in PSG
 - b) measuring and applying electrodes according to guidelines
 - c) performing patient and instrument calibrations according to guidelines, and
 - d) obtaining a ten minute baseline recording;
- 4) explaining (verbal or written) common sleep disorders and treatment options; and,
- 5) performing the multiple sleep latency test (MSLT) and the maintenance of wakefulness test (MWT).

d. INTRODUCTORY NERVE CONDUCTION STUDIES (NCS)

Competency at the introductory level is evidenced by a graduate's knowledge and ability in the following areas:

- 1) identifying basic peripheral nerve and muscle anatomy and physiology;
- 2) describing the general scope of neuromuscular disorders (e.g., neuron, axon, myelin sheath, neuromuscular junction, and muscle);
- 3) explaining the principles of stimulation and accurate placement of recording electrodes; and,
- 4) defining the principles of measuring waveforms and distances used in routine nerve conduction studies.

e. INTRODUCTORY LONG TERM MONITORING (LTM)

Competency at the introductory level is evidenced by a graduate's knowledge and ability in the following areas:

- 1) explaining indications for long-term monitoring for epilepsy and basic LTM procedures, including:
 - a) ambulatory EEG
 - b) monitoring with surface leads and intracerebral leads using video/EEG and
 - c) continuous EEG intensive care monitoring;
- 2) recognizing and explaining instrumentation for long-term monitoring;
- 3) explaining treatment options for epilepsy; and,
- 4) identifying common seizure patterns.

f. INTRODUCTORY INTRAOPERATIVE NEUROPHYSIOLOGICAL MONITORING (IONM)

Competency at the introductory level is evidenced by a graduate's knowledge and ability in the following areas:

- 1) explaining common indications for intraoperative neurophysiological EEG, evoked potential and neuromuscular monitoring;
- 2) recognizing criteria for significant changes during intraoperative monitoring;
- 3) defining effects of common anesthetic agents; and,
- 4) stating common effects of physiological variables on monitoring results.

GROUP 2 (optional add-on): The following Graduate Competencies for performing Evoked Potential Studies (EPs) build on the Group 1 NDT Graduate Competencies. Both groups of competencies are required in Neurodiagnostic Technology (NDT) programs that choose to develop an EP add-on.

a. Evoked Potential (EP)

Entry-level competency is evidenced by a graduate's knowledge and ability in the following areas:

1) Preparing a patient data form that includes:

- a) patient information (e.g., name, age, gender, ID number, doctor);
- b) procedure number, recording time, date, and graduate's name or initials;
- c) significant, relevant medical history, sensory complaints and clinical findings specific to the modality studied and reason for study;
- d) patient's mental, behavioral, and consciousness states;
- e) all patient medications;
- f) results of other clinical studies relevant to the EP modality being tested, such as audiogram for BAEP, visual field testing for VEP, and nerve conduction studies for SEP; and,
- g) description of relevant events that occurred during the testing procedure (including troubleshooting steps).

2) Applying electrodes by following a method that includes:

- a) measuring the patient's head using the International 10/20 system and/or Queen Square method of electrode placement as appropriate for the evoked potential;
- b) prepping patient's scalp and skin prior to electrode application;
- c) using standard disc type electrodes or needle electrodes, as appropriate;
- d) using additional electrodes or modified placements as needed or as indicated by lab policy;
- e) applying disc electrodes with paste or with collodion and electrolyte;
- f) verifying that electrode impedances are balanced and below 5000 ohms; and,
- g) ensuring integrity of the recording, stimulating and ground electrodes.

3) Verifying the integrity of the Evoked Potential instrument by:

- a) calibrating with a square pulse of appropriate amplitude and using parameters that will be used for the recording;
- b) recognizing and correcting malfunctions seen with calibration, if possible;
- c) assuring that all equipment has been checked for safety and there is a current biomedical inspection sticker; and,
- d) reporting equipment malfunctions to the appropriate individuals, according to lab policy.

4) Obtaining a standard EP recording that includes:

- a) clearly resolved waveforms;
- b) at least two replications demonstrating consistency of latency and amplitude measurements;
- c) use of appropriate recording and stimulus parameters;
- d) additional electrode derivations and other techniques as needed to enhance or clarify the abnormality; and,
- e) obligate peaks displayed according to recommended standard or department policy.

5) Identifying and eliminating or reducing artifacts contaminating the waveforms by:

- a) checking the quality of the raw signal regularly or whenever needed;
- b) understanding the meaning and significance of artifact rejection;
- c) understanding the relationship of signal to noise ratio;
- d) recognizing whether the artifact is physiologic or non-physiologic;
- e) identifying source of the artifact (poor electrode application, malfunctioning stimulator, or positioning of cables);
- f) calculating frequency in Hz of rhythmic artifacts (including calculation to identify 60 Hz artifact);
- g) understanding the effects of aliasing, proper grounding of the patient and equipment; and,
- h) enhancing signal to noise ratio by increasing the number of sweeps.

6) Completing the EP recording by:

- a) removing electrode paste/glue from patient's scalp, hair and skin;
 - b) preparing a detailed test data worksheet that includes: montage; time and voltage calibration scales; filter settings; side stimulated; stimulus parameters-type, (polarity, rate, duration, delay, masking, intensity, and visual angle); number of trials averaged; polarity convention; and other modality-specific relevant information such as visual acuity, hearing thresholds, limb length and height;
 - c) documenting sedation used, dosage, and effect (if applicable);
 - d) marking the obligate peaks and documents their latencies and amplitudes;
 - e) preparing hard copy of the waveforms; and,
 - f) storing information on electronic media according to department policy.
- 7) Demonstrating an understanding of the following concepts by:**
- a) identifying evoked potential components and how to measure latencies and amplitudes of obligate peaks;
 - b) explaining basic electricity and electronics;
 - c) correlating basic functional neuroanatomy and neurophysiology;
 - d) describing anatomy of EP systems and generators of EP components;
 - e) using medical terminology and accepted abbreviations;
 - f) explaining EP correlates of neurologic, orthopedic, neurosurgical, and audiologic disorders;
 - g) identifying pathologic and non-pathologic factors affecting EPs;
 - h) recognizing the technical aspects, electrical hazards, & recording techniques unique to hostile environments (e.g., ICU, OR, radiology suites); and,
 - i) explaining EP normative data.
- 8) Applying the principles and concepts of EP instrumentation to the recording by:**
- a) averaging signals and reducing noise;
 - b) converting analog to digital data, including vertical and horizontal resolution, sampling rate, analysis time, sampling interval (dwell time), and Nyquist frequency;
 - c) discussing the function of differential amplifiers including input impedance, common mode rejection, polarity convention, and gain;
 - d) describing effects of stimulus and recording parameters on EP waveforms;
 - e) explaining electrode impedance and its importance; and,
 - f) adhering to electrical safety standards.
- 9) Recording a technically adequate Brainstem Auditory Evoked Potential by:**
- a) obtaining relevant audiologic, neurologic, and/or neurosurgical history, (e.g., hearing loss, ear infections, dizziness, tinnitus);
 - b) assessing the patient's ear canals for foreign bodies or cerumen;
 - c) establishing hearing thresholds;
 - d) correlating elevations in thresholds with any existing hearing loss or conditions of ear structures;
 - e) noting the results of prior hearing evaluations;
 - f) using a montage derivation of vertex to ipsilateral and vertex to contralateral ears;
 - g) choosing the appropriate timebase, number of stimuli, sensitivity and bandpass settings;
 - h) choosing the appropriate click polarity, rate and intensity;
 - i) expressing click intensity measures in equivalent units of dBSL, dBHL or dB SPL;
 - j) adequately resolving of the obligate waves I, III, and V;
 - k) using techniques to enhance wave I resolution such as an ear to ear montage or using an ear canal electrode or increasing stimulus intensity or changing click polarity;
 - l) measuring and calculating the absolute latencies, amplitudes and interpeak intervals of obligate peaks;
 - m) masking of opposite ear and understanding its use and effects; and,
 - n) performing a latency intensity series for auditory assessment in infants & other patients whenever indicated.

10) Obtaining a technically adequate Somatosensory Evoked Potential (SEP) by:

- a) obtaining relevant neurologic, orthopedic, and/or neurosurgical history or any other relevant pathway specific information such as the presence of peripheral neuropathy;
- b) selecting appropriate timebase, sensitivity and bandpass settings;
- c) applying the appropriate stimulating electrodes: active cathode over the nerve and anode placed distally;
- d) properly grounding the patient to reduce stimulus artifact;
- e) selecting current of sufficient intensity and duration to elicit a motor twitch from the appropriate areas of stimulation;
- f) using a montage that records responses from multiple levels of the pathway such as peripheral nerve, spinal cord, subcortical, and cortical responses;
- g) adequately resolving of the obligate components of Erbs Point, N13, P14, N18, and N20 of the median nerve SEP;
- h) adequately resolving the EP components of popliteal fossa and obligate waveforms such as the LP, N34, and P37 of the posterior tibial nerve SEP;
- i) marking waveforms & calculating the absolute latencies, amplitudes and interpeak intervals of the obligate components;
- j) calculating peripheral nerve conduction velocity; and,
- k) using additional techniques that clarify the abnormalities seen.

11) Obtaining a technically adequate Visual Evoked Potential by:

- a) obtaining relevant ophthalmologic and neurologic history;
- b) using a montage that records responses from both hemispheres;
- c) assessing the patient's visual acuity;
- d) selecting an adequate check size and positioning the patient at a distance from the pattern stimulator appropriate for the desired visual angle;
- e) closely monitoring of the patient's attention during the test;
- f) performing the study with the same parameters and conditions used for normative studies including ambient light, pattern luminance and contrast;
- g) adequately recording peaks N75, P100, N145;
- h) adequately resolving a "W" shaped waveform;
- i) measuring and calculating the absolute latency, amplitude, amplitude ratios and intraocular latency difference of P100;
- j) using flash stimuli in selected patients when use of pattern reversal stimulus is not possible;
- k) understanding the limitations of use of flash stimuli; and,
- l) using hemifield testing when indicated to clarify asymmetries or other abnormalities.

GROUP 3 (optional add-on): The following Graduate Competencies for performing Polysomnography studies (PSG) build on the Group I NDT Graduate Competencies. Both groups of competencies are required in Neurodiagnostic Technology (NDT) programs that choose to develop a PSG add-on.

a. Polysomnography (PSG)

Entry-level competency is evidenced by a graduate's knowledge and ability in the following areas:

1) Demonstrating an understanding of polysomnography by:

- a) following the principles of polysomnography and asking the clinically relevant questions to be answered for each individual patient;
- b) applying medical terminology and accepted abbreviations in sleep disorders medicine;
- c) applying concepts of basic electricity and electrical safety;
- d) recognizing anatomy and physiology, especially cardiopulmonary and neurologic;
- e) correlating polysomnographic patterns with specific disorders;
- f) correlating basic breathing mechanisms and airway physiology;
- g) reviewing current medications and recognizing their effects on the recordings;
- h) identifying therapeutic modalities (e.g., mechanical, pharmacological, surgical);
- i) following Standard Precautions and Transmission Based Precautions for infection prevention; and,
- j) demonstrating appropriate ethical professional behaviors.

2) Identifying indications for sleep studies by:

- a) using the International Classification of Sleep Disorders and relevant practice parameters;
- b) recognizing signs and symptoms for adult sleep disorders;
- c) recognizing signs and symptoms for pediatric sleep disorders;
- d) recognizing seizure manifestations and classifications; and,
- e) recognizing psychiatric and psychological disorders.

3) Preparing for the study by:

- a) assessing the physician's order to assure appropriateness in conjunction with reviewing of the patient's medical records;
- b) interviewing the patient to obtain any additional information;
- c) determining and accommodating the patient's age-specific needs, disability and/or other special needs;
- d) providing appropriate patient and family education including expectations of technical procedures;
- e) answering questions related to sleep disorders testing;
- f) determining the need for additional physiological monitors; and,
- g) determining the possible need for emergency intervention.

4) Preparing a worksheet that includes:

- a) patient demographic information (e.g., name, age, gender, ID number, referring physician, reason for referral);
- b) procedure information (e.g., procedure type, procedure number, date of test, technologist name, recording time.);
- c) chief complaint, relevant medical history and clinical findings specific to procedure;
- d) sleeping medications taken or administered during the study; and,
- e) identifying any special circumstances necessitating changes in usual protocols.

5) Verifying the integrity of the PSG recording equipment by:

- a) performing an all-channel and montage calibration before lights out;
- b) recognizing and correcting recording equipment malfunction observed during calibration including polysomnography amplifiers, ancillary equipment and audiovisual equipment;
- c) performing an end-of-study calibration procedure to verify the integrity of recorded data; and,
- d) verifying the presence of a current biomedical inspection sticker.

6) Applying electrodes and sensors by following a method that includes:

- a) identifying the appropriate method and site of electrode application;

- b) determining setup and recording protocols including montage derivations;
- c) using standard precautions during patient preparation;
- d) measuring the patient's head according to the International 10/20 system of electrode placement;
- e) prepping patient's scalp and skin prior to electrode application;
- f) following established protocols for placement of ECG, EMG, EOG and other recording electrodes and sensors used in polysomnography, i.e., nasal/oral airflow, effort devices and oximeter sensors;
- g) utilizing additional electrodes or modified placements based on the patient's history or medical needs;
- h) ensuring security and integrity of electrodes and sensors for an extended period of time; and,
- i) verifying and documenting electrode impedances are balanced and below 5,000 ohms on the face and scalp, 10,000 ohms on the legs.

7) Obtaining an accurate patient recording by:

- a) acquiring, verifying and documenting biological calibrations prior to "lights out" to document integrity of the physiological monitors;
- b) recognizing the effects of recording parameters on waveforms (i.e., filter settings, sensitivity settings);
- c) recognizing, troubleshooting and minimizing artifacts so that sleep stages and all monitoring channels are clearly readable throughout the recording;
- d) recognizing and documenting relevant data, including but not limited to, body position changes, life-threatening events, EEG and ECG abnormalities;
- e) documenting routine changes periodically throughout the recording to include notes on observed behavior, parasomnias, notations of montage and equipment settings; and,
- f) recognizing the need for clinical interventions (e.g., oxygen, positive airway pressure titration, CPR) and performing them according to established guidelines.

8) Completing the PSG recording by:

- a) removing electrodes and sensors from the patient;
- b) documenting a summary of the polysomnogram and clinical observations in order to assist with the interpretation (e.g., estimated apnea index, apnea-hypopnea index, estimated periodic limb movement index, clinically significant behavior, significant cardiac arrhythmia, lowest oxygen desaturation);
- c) preparing patient data and chart for scorer;
- d) performing transfer of data or data backup in accordance with department specific protocols; and,
- e) cleaning and disinfecting electrodes and other reusable equipment according to manufacturer's guidelines and/or established department protocols.

9) Scoring the polysomnogram in accordance with The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology, and Technical Specifications which includes:

- a) sleep stages;
- b) arousal events;
- c) respiratory events;
- d) differentiation between potentially lethal and non-lethal ECG patterns; and,
- e) periodic limb movement events.

10) Providing a technical report that includes:

- a) sleep scoring data: lights out/on, total sleep time, total recording time, sleep latency, stage R latency, wake after sleep onset, percent sleep efficiency, time in each stage, percent of total sleep time in each stage;
- b) arousal events: number of arousals, arousal index;
- c) respiratory events: note the presence and number of obstructive/mixed/central sleep apneas and hypopneas, number of apneas + hypopneas, apnea index, hypopnea index, apnea + hypopnea index, continuous oxygen saturation mean value, minimum oxygen saturation during sleep, occurrence of Cheyne Stokes breathing;

- d) cardiac events: note the presence and average heart rate and highest heart rate during sleep, highest heart rate during recording, and the occurrence of the following arrhythmias, listing heart rate or duration of pause:
 - (i) bradycardia – report lowest heart rate observed;
 - (ii) asystole – report longest pause observed;
 - (iii) sinus tachycardia during sleep – report highest heart rate observed;
 - (iv) narrow complex tachycardia – report highest heart rate observed;
 - (v) wide complex tachycardia – report highest heart rate observed;
 - (vi) atrial fibrillation; and,
 - (vii) the presence of other arrhythmias that may be present;
- e) movement events: number of periodic limb movements of sleep (PLMS) with/without arousals, PLM index, PLM arousal index; and,
- f) summary statements: findings related to sleep diagnosis; EEG abnormalities; ECG abnormalities; behavioral observations; and summary of therapeutic intervention.

11) Applying and recording data from the following electrodes and sensors as appropriate:

- a) respiratory inductance plethysmography;
- b) nasal/oral thermistor/thermocouple;
- c) nasal pressure transducer;
- d) snore microphone/sensor;
- e) pulse oximetry;
- f) end-tidal CO₂ monitor;
- g) transcutaneous CO₂ monitor; and,
- h) other monitoring devices.

12) Performing positive airway pressure titration by:

- a) assuring the positive airway pressure device is calibrated appropriately and interfaced properly to the polysomnography recording equipment;
- b) explaining sleep apnea and the role of positive airway pressure to the patient during the setup process, and answering any questions;
- c) sizing the patient with a mask and allowing the patient to adjust to wearing it while awake and sitting up prior to starting the recording;
- d) understanding the contraindications and complications of positive airway pressure therapy;
- e) identifying when to adjust the pressure to achieve optimal delivery (e.g., snoring, arousals, desaturations) and providing documentation and reasons for changes in positive airway pressure;
- f) verifying optimal pressure during Stage R and supine sleep if possible;
- g) identifying and correcting factors that may compromise delivery of effective positive airway pressure
- h) pressures, i.e., substantial mask leakage or mouth breathing;
- i) recognizing the need to change to bi-level positive airway pressure if needed;
- j) recognizing when to contact the medical director;
- k) maintaining proper cleaning and disinfection and maintenance of the positive airway pressure device; and,
- l) differentiating the different types of positive airway pressure.

13) Performing oxygen titration by:

- a) ensuring that a physician's order is obtained prior to administration;
- b) determining the need for supplemental oxygen by following established laboratory protocols for oximetry;
- c) assuring proper function of equipment providing oxygen delivery;
- d) recognizing contraindications for supplemental oxygen;
- e) properly fitting and adjusting the nasal cannula for oxygen delivery with or without positive airway pressure and humidification devices;
- f) incorporating the use of combined positive airway with pressure with supplemental oxygen;
- g) recognizing when to adjust supplemental oxygen to achieve optimal oxygen saturation levels;
- h) identifying signs that the patient's drive to breathe is reduced and making appropriate adjustments; and,

- i) documenting changes in oxygen saturation on the PSG and the technologist summary report.

14) Performing the Multiple Sleep Latency Test (MSLT) by:

- a) verifying and documenting use and/or discontinuation of all prescription medications, over-the-counter medications, herbal and dietary supplements, and other substances and/or activities that would affect sleep or wakefulness;
- b) documenting by polysomnography the previous night's sleep to verify the appropriateness of the MSLT order;
- c) obtaining a urine drug screen test if ordered;
- d) following established guidelines for the performance of the MSLT procedure;
- e) administering questionnaires as required; and,
- f) providing documentation and reports as required by lab protocols for interpretation.

15) Performing the Maintenance of Wakefulness Test (MWT) by:

- a) verifying a drug history was obtained and any medications discontinued for two weeks prior to testing as deemed necessary by the referring physician;
- b) obtaining a urine drug screen test if needed, as order;
- c) following established guidelines for the performance of the MWT procedure;
- d) administering questionnaires as required; and,
- e) providing documentation and reports as required by lab protocols for interpretation.

GROUP 4 (optional add-on) The following Graduate Competencies for performing Nerve Conduction Studies (NCS) build on the Group I NDT Graduate Competencies. Both groups of competencies are required in Neurodiagnostic Technology (NDT) programs that choose to develop an NCS add-on.

a. Nerve Conduction Studies (NCS)

Entry-level competency is evidenced by the graduate's knowledge and skill in the following areas:

1) Preparing for the study by:

- a) obtaining a relevant medical history from the patient including current medications (that might affect NMJ patients) and whether patient has a pacemaker/ICD.
- b) ensuring that the laboratory or testing site adheres to Occupational Safety and Health Administration (OSHA) standards;
- c) ensuring that Standard Precautions and Transmission Based Precautions are followed;
- d) complying with HIPAA regulations, e.g., confidentiality, two patient identifiers;
- e) explaining the procedure to the patient;
- f) communicating with the patient at an age and educationally appropriate level;
- g) addressing any patient concerns regarding the test;
- h) ensuring that filters, sensitivity and time base are accurate according to protocol;
- i) adequately preparing the skin to reduce impedance; and,
- j) assessing limb temperature and warming the limbs, if needed.

2) Identifying and eliminating or reducing artifact by:

- a) positioning the patient to ensure adequate accessibility and patient comfort;
- b) removing or unplugging equipment (e.g., diathermy machine, fluorescent lighting), and unplugging the bed if position adjustment motors are present;
- c) creating an environment that is optimal for patient relaxation;
- d) cleansing the skin where the electrodes will be placed to reduce skin impedance;
- e) assuring correct cathode/anode orientation of the stimulator;
- f) recognizing, identifying and resolving artifact, and determining whether it is physiologic or non-physiologic;
- g) beginning stimulus at a low intensity level and slowly increasing intensity with each stimulus given;
- h) verifying correct nerve stimulation by observing appropriate muscle contraction; and,

3) Completing the study by:

- a) removing recording electrodes and cleaning electrode and stimulation sites according to recommended established guidelines;
- b) calculating conduction velocities, latencies, and amplitudes using basic mathematical principles;
- c) storing copy of study according to facility protocol (paper, electronic media); and,
- d) disinfecting (or disposing if disposable) recording electrodes, stimulator probe, temperature probe and stretcher/bed according to Standard Precautions and Transmission Based Precautions.

4) Describing the benefit of future ongoing professional development for continuing competence post-graduation through the:

- a) review of neurodiagnostic procedures with the interpreting physician on a regular basis; and,
- b) acquisition of continuing education units (CEU).

5) Documenting the following for physician review:

- a) relevant medical history;
- b) waveform latencies in milliseconds;
- c) waveform amplitudes in microvolts or millivolts, as applicable for study;
- d) conduction velocities in meters/second, if applicable;
- e) limb temperature;
- f) any anatomical variants, e.g., Martin-Gruber anastomosis, accessory peroneal;
- g) any unusual characteristics of the waveforms; and,

- h) any technical difficulties encountered.
- 6) Recognizing the difference between normal and abnormal waveforms by:**
- a) stating the physiology of the study being performed;
 - b) explaining the importance of normative data;
 - c) performing studies with adherence to Standard Precautions and Transmission Based Precautions;
 - d) discussing the cause for variance (e.g., artifact related to stimulus spread, volume conduction, stimulus artifact and appropriate use of maximal and supramaximal stimulation) vs. disease vs. anomaly;
 - e) explaining the importance of accurate and consistent measurements;
 - f) discussing the importance of limb temperature and its effect on results;
 - g) describing the effect that height can make on certain studies including conduction velocities, F-waves and H-reflexes;
 - h) stating the relevance of abnormalities as associated with clinical symptoms; and,
 - i) explaining the importance of waveform configuration.
- 7) Adhering to the following with regard to electrical safety by:**
- a) calibrating or have qualified personnel calibrate the electromyography (EMG)/NCS equipment as recommended by the facility's protocol or equipment manufacturer guidelines;
 - b) ensuring the equipment is turned on prior to applying electrodes to the patient and ensuring electrodes are removed from the patient prior to turning off equipment;
 - c) ensuring equipment is grounded with a 3-prong electrical plug and outlet;
 - d) providing proper grounding for the patient, ensuring that additional conductor near the patient does not form a "ground loop";
 - e) stating the physiology of electrical safety in electrically sensitive patients (e.g., pacemakers, cardiac catheters);
 - f) performing studies with the electrodes plugged only into the equipment amplifier; and,
 - g) guaranteeing the equipment is clear of all liquids.
- 8) Adhering to the following with reference to the stimulator by:**
- a) using a conductive solution (saline or electrode gel) on the stimulator to maximize conductivity;
 - b) determining stimulation intensity to produce the proper waveforms by using milliamps (0 to 99 mA) or volts (0 to 400V);
 - c) explaining the difference between constant current and constant voltage;
 - d) using the proper stimulus pulse duration (0.05 msec to 1.0 msec), with the correct stimulus intensity and applying maximal and supramaximal stimulation where appropriate for each study; and,
 - e) using the stimulator correctly via the anode (+) and cathode (-) to produce the appropriate waveforms and ensuring desired polarity for the particular study being performed.
- 9) Adhering to the following with reference to the electrodes used in nerve conduction studies by:**
- a) cleaning the electrode site to reduce skin impedance;
 - b) correlates the basis of the active, reference, and ground electrodes as they apply to each study;
 - c) applying surface electrodes using disposable or metal electrodes with conductive gel;
 - d) evaluating how skin resistance (i.e. oily or rough skin) affects electrode impedance;
 - e) positioning electrodes correctly for each study as determined by protocol and normal values; and,
 - f) ensuring that the ground is placed between stimulating and recording sites.
- 10) Adhering to the following with reference to the equipment amplifier by:**
- a) recording the nerve conduction study at the appropriate sensitivity for each procedure;
 - b) explaining the function of differential amplifiers, including input impedance, common mode rejection, and polarity convention;
 - c) maintaining consistent sensitivity settings and filter settings for each study in accordance with normal values;
 - d) selecting proper filter settings for each study;
 - e) using motor settings that filter frequencies below 2 Hz and above 20kHz;
 - f) using sensory settings that filter frequencies below 20 Hz and above 3 kHz;

- g) stating the effects of filter settings on each study;
- h) stating the principles associated with averaging sensory responses;
- i) selecting the proper time base for each study;
- j) ensuring that the entire waveform acquired is fully displayed on the monitor and is expressed in milliseconds per division, or full screen milliseconds; and,
- k) troubleshooting artifact (electrical, 60 Hz, muscle, movement, or stimulus artifact) and eliminating it.

11) Obtaining F-Wave studies utilizing steps that include:

- a) placing recording, reference, and ground electrodes, utilizing anatomical sites for study being performed;
- b) having a completed motor study on the nerve from which the F-wave will be obtained to assess nerve status;
- c) orienting stimulator probe so that the anode is distal to the cathode, increasing from a low stimulus intensity to supramaximal until a series of sample F-waves can be obtained;
- d) displaying and measuring waveforms according to protocol/recommended standards;
- e) performing additional studies if necessary to clarify abnormalities;
- f) recording comparison studies on the contralateral side if normal values are not established; and
- g) recognizing the difference between normal and abnormal waveforms:
 - (i) causes for variance, i.e. artifact vs. disease;
 - (ii) relevance of abnormalities associated with clinical symptoms;
 - (iii) uses of sensitivity, intensity, time base, and duration to optimize responses; and,
 - (iv) appropriate studies to provide clarification of disease process and /or clinical correlation to aid the physician in determining diagnoses.

12) Obtaining H-wave studies utilizing steps that include:

- a) placement of recording, reference and ground electrode utilizing anatomical sites for the study being performed;
- b) orienting the stimulator probe so the anode is distal to the cathode;
- c) using appropriate submaximal stimulus level and long duration level to obtain optimal results;
- d) obtaining a series of waveforms showing initial appearance of H-reflex from onset through maximal height of amplitude and subsequent attenuation of H-reflex waveform with corresponding increase in motor response;
- e) displaying waveforms according to protocol/recommended standards;
- f) obtaining waveform measurements according to protocol/recommended standards;
- g) obtaining studies tailored to patient history, maximizing information for best diagnostic capability; and,
- h) obtaining comparison studies on the contralateral side; and,
- i) recognizing the difference between normal and abnormal waveforms, including
 - (i) causes for variance, i.e. artifact vs. disease;
 - (ii) relevance of abnormalities associated with clinical symptoms;
 - (iii) uses of sensitivity, time base, intensity, and duration to maximize responses;
 - (iv) observes appropriate limb movement with stimulation of the nerve; and,
 - (v) determines appropriate studies to provide clarification of disease process and/or clinical correlation to aid physician in determining diagnoses.

13) Performing repetitive nerve stimulation (RNS) studies using steps that include

- a) assessing recording site temperature;
- b) obtaining a pre-repetitive supramaximal motor conduction study to assess nerve function and ensuring correct electrode placement;
- c) ensuring the patient has not taken any form of cholinesterase inhibitor, such as Mestinon®, within the last 12 hours;
- d) securing the stimulus probe in a manner that ensures consistent stimulus in a precise location;
- e) securing the stimulating electrodes to the skin to reduce movement artifact;
- f) utilizing 2-50 Hz to stimulate the nerve;
- g) obtaining at least one pre-exercise repetitive stimulations utilizing a train stimuli determined by protocol to ensure optimal placement of electrodes and to note any pre-exercise decrement;

- h) isometrically exercising the patient's muscle and describing how the exercise protocol affects the study (either through directives to the patient, or using rapid repetitive stimulus if the patient is unable to cooperate);
- i) instructing the patient to relax post-exercise;
- j) continuing to test in time intervals as described in protocol;
- k) continually supporting the patient through verbal reassurance;
- l) ensuring waveforms are displayed in accordance with protocol/recommended standards;
- m) recognizing the difference between an abnormal and normal set of waveforms, including:
 - (i) stating the applications of RNS in assessing the neuromuscular junction;
 - (ii) explaining the difference between a decremental and incremental response;
 - (iii) recognizing presence of nonartifactual decremental response and its significance; and,
 - (iv) recognizing variations of waveforms that can be the result of other neurological disorders, such as myasthenia gravis, botulism poisoning or Lambert-Eaton.

14) Obtaining the blink reflex study utilizing steps that include:

- a) placement of the grounding electrode to the appropriate site;
- b) placement of the recording electrode over the orbicularis oculi bilaterally;
- c) placement of the reference electrode over the lateral canthus bilaterally;
- d) connecting the electrodes from the stimulated side of the face into the EMG instrument to display appropriate responses;
- e) connecting the electrodes from the contralateral stimulated side of the face into the EMG instrument to display appropriate responses;
- f) locating the supraorbital notch for stimulation;
- g) ensuring that the cathode is distal to the anode;
- h) applying the stimulus at a slow rate and low intensity level, increasing with each subsequent stimulus given until optimal response is recorded;
- i) maintaining dialogue with patient to prepare him/her for next stimulus;
- j) ensuring correct nerve stimulation by observing muscle response, i.e. blinking of the eyes;
- k) recording 3 to 4 waveforms representing the R1 ipsilateral, R2 ipsilateral and R2 contralateral components if obtainable;
- l) measuring latencies for each of the R1 ipsilateral, R2 ipsilateral and R2 contralateral components;
- m) repeating the process for the contralateral side;
- n) ensuring waveforms are displayed according to policy/recommended standards;
- o) recognizing the difference between normal and abnormal waveforms, including:
 - (i) recognizing the presence or absence of all components (R1, R2, R2 prime) and their significance; and,
 - (ii) recognizing variations of waveforms for various disease processes, i.e. Bell's palsy, cerebropontine angle tumors, Guillain-Barre syndrome, and multiple sclerosis.
- p) recognizing habituation of waveforms and how to decrease that effect.

15) Correlating the patient history and clinical symptoms in order to determine the appropriate nerve conduction studies in the following disease processes by:

- a) explaining anatomy and physiology of the peripheral nervous system and its related disorders (e.g., Diabetic neuropathy, AIDP, CIDP, ALS, SMA);
- b) discussing anatomy and physiology of the central nervous system and its related disorders and cranial nerve testing (e.g., motor neuron disease, Multiple Sclerosis, Bells Palsy);
- c) describing anatomy and physiology of the NMJ and disorders of neuromuscular transmission (e.g., myasthenia gravis, Lambert-Eaton, botulism poisoning);
- d) describing pre- and post-ganglionic lesions;
- e) describing brachial plexus injuries/lesions;
- f) describing lumbar plexus injuries/lesions;
- g) describing radiculopathy;

- h) explaining mononeuropathies including but not limited to median at the wrist (Carpal Tunnel Syndrome); ulnar at the elbow and Guyon's canal; tibial at the ankle (tarsal tunnel); and, peroneal at fibular head; and,
- i) discusses neurapraxia (conduction block), axonotmesis and neurotmesis.

GROUP 5 (optional add-on): The following Graduate Competencies for performing Long Term Monitoring Studies (LTM) build on the Group I NDT Graduate Competencies. Both groups of competencies are required in Neurodiagnostic Technology (NDT) programs that choose to add-on LTM.

a. Long Term Monitoring (LTM)

Entry-level competency is evidenced by a graduate's knowledge and ability in the following areas:

1) Demonstrating the technical skills in long-term monitoring by:

- a) following American Clinical Neurophysiology Society (ACNS) and international guidelines for head measurement (10/20 or 10/10 international systems) of electrode placement;
- b) applying electrodes using the appropriate application method (e.g., paste, collodion, or electrode caps);
- c) ensuring electrode security and integrity;
- d) following policies for infection control;
- e) ensuring electrodes and other direct patient contact supplies are cleaned and disinfected as documented in ASET infection control position statement;
- f) verifying and documenting sedation is ordered by the attending physician and administered by the resident or the staff nurse, and assisting nursing staff in monitoring the patient appropriately;
- g) following patient safety protocols, especially those for seizure;
- h) maintaining Cardiopulmonary Resuscitation (CPR) certification and following the hospital code for Cardiorespiratory arrest;
- i) following the unit procedures for high patient acuity (severity of the patient's condition), e.g., respiratory distress or arrest codes, contagious diseases, death;
- j) recognizing artifacts and minimizing, or when possible, eliminating artifact on recordings in all electrically hostile units such as the operating room (OR);
- k) reformatting data and applying data reduction techniques;
- l) using computer operations and networking sufficiently to perform basic troubleshooting and to report findings to IT support services;
- m) creating custom montages using implanted electrodes or additional non-standard electrodes;
- n) recognizing EEG seizure activity, and conducting seizure interview and technical neuroassessment during seizures;
- o) alerting the nurse of the occurrence of subclinical and clinical seizure activity;
- p) recognizing and acting appropriately when a patient experiences a respiratory or cardiopulmonary arrest, initiating CPR procedures as needed;
- q) completing and maintaining patient documentation for charges, statistics, and medical records; and,
- r) demonstrating supportive behaviors necessary for age-specific care.

2) Demonstrating an understanding of LTM by:

- a) using medical terminology and accepted abbreviations in LTM;
- b) identifying basic electricity and electronic concepts of LTM equipment;
- c) applying basic safety practices related to the patient and the patient's LTM biomedical equipment;
- d) explaining basic functional neuroanatomy and neurophysiology relevant to LTM;
- e) recognizing anatomical correlation of EEG waveforms;
- f) recognizing electrographic correlates of clinical conditions such as generalized tonic-clonic seizures, complex partial seizures, and nonepileptic events;
- g) describing seizure terminology; and,
- h) demonstrating infection control standards (sterile techniques regarding patient and equipment);

3) Recognizing the indications for LTM by:

- a) identifying the diagnosis of epilepsy;
- b) classifying and characterizing seizures;
- c) quantifying seizures; and,
- d) recognizing the difference between recordings from surface or implanted electrodes to localize

4) Performing LTM recording options by:

- a) using scalp electrodes without video, continuous trace EEG;
 - b) applying electrodes with video;
 - c) adding scalp and/or sphenoidal electrodes without video; and,
 - d) applying scalp and/or sphenoidal electrodes with video.
- 5) Demonstrating the details of LTM instrumentation by:**
- a) identifying various types of recording and storage media;
 - b) explaining concepts of digital recording, including appropriate sampling rates, aliasing, Nyquist frequency, sampling skew, amplitude resolution, horizontal resolution (analysis time), and digital video specifications;
 - c) discussing the effects of recording parameters (filters, gain/sensitivity) on EEG waveforms;
 - d) verifying electrode impedance test;
 - e) ensuring electrical safety of equipment;
 - f) using and explaining automatic seizure detection software including the application of basic algorithms used for detection;
 - g) explaining parameters used in event detection, and their effects;
 - h) using a computer to organize file structures and maneuvering around a menu environment;
 - i) applying and adjusting appropriate calibration for analog or digital recording;
 - j) describing the technique of reformatting system references; and,
 - k) explaining audio/video instrumentation, including digital video technology.
- 6) Performing duties specific to LTM by:**
- a) using electrode application techniques appropriate for extended monitoring and for patients in critical care settings;
 - b) using appropriate activation procedures per physician's order such as photic stimulation, hyperventilation, sleep deprivation, and /or any patient specific activation;
 - c) reviewing events detected by automated spike/seizure detection system; and,
 - d) printing EEG from stored computer data.
- 7) Selecting appropriate recording parameters and customizing these parameters based on the case by:**
- a) reviewing, analyzing, and extracting clinical events from recorded data;
 - b) adjusting video recording system and troubleshooting problems;
 - c) using safety precautions when caring for patients having seizures;
 - d) assisting in the care and transfer of patients; and,
 - e) transporting recording equipment as needed.
- 8) Recognizing various types of electrodes used in the clinical setting, including:**
- a) scalp – disk;
 - b) scalp – needle;
 - c) sphenoidal;
 - d) monitoring electrodes (e.g., eye movement, EMG, respiratory);
 - e) intracranial electrodes;
 - f) subdural strips, grids, cylinders;
 - g) epidural strips, grids;
 - h) depth electrodes; and,
 - i) different electrode metals and their effects on EEG recording.
- 9) Demonstrating the verification process to check the integrity of LTM equipment by:**
- a) calibrating system amplifiers;
 - b) ensuring audio/video equipment is working properly; and,
 - c) verifying patient event alarms.
- 10) Acquiring information and assisting in evaluating the patient and his/her needs prior to the procedure by:**
- a) reading medical records;
 - b) interviewing patient;

- c) interviewing family/friends;
- d) discussing with referring physician;
- e) viewing previously recorded data;
- f) determining and accommodating the patient's age-specific needs (e.g., mental age, state, comprehension level, disability, and/or special needs);
- g) providing appropriate patient education including expectations and guidelines while in the monitoring unit and explanation of technical procedures, such as limitation of movement, use of event signal devices, continuous audio/video recording, and some loss of privacy;
- h) answering questions relating to the LTM monitoring procedure; and,
- i) answering questions (education/ information) related to subsequent testing procedures, Wada, cEEG, PET, FMRI, SPECT, Neuropsychological testing, etc.

11) Preparing a basic data sheet that includes:

- a) patient demographic information (i.e., name, age, ID number);
- b) procedure information: number, recording time, date, technologist's initials;
- c) significant relevant medical history and clinical findings specific to procedure;
- d) seizure or event types, description, duration, and frequency, first and last event;
- e) patient's mental, behavioral, consciousness, and neuro-assessment baseline states;
- f) all patient medications, drug levels if available; and,
- g) results of studies relevant to LTM (PET, cEEG, MRI, neuropsychology, SPECT).

12) Following a method of electrode application that includes:

- a) identifying appropriate method of electrode application;
- b) checking supplies, number of electrode jackboxes, interconnector cables, and amplifiers for each patient;
- c) determining set-up and recording protocols including montage derivations appropriate for the patient;
- d) using standard precautions during patient preparation;
- e) using physician-ordered placement of additional electrodes;
- f) ensuring security and integrity of electrodes for an extended period of time;
- g) measuring the patient's head according to the International 10/20 System of electrode placement;
- h) cleaning patient's scalp and skin prior to electrode application;
- i) maintaining sterility of incision and implant site;
- j) discarding or autoclaving electrodes that come in contact with body fluids;
- k) placing appropriate recording reference and ground electrodes in digital recording systems and using spares whenever necessary; and,
- l) assessing the patient's potential for skin breakdown and taking steps to minimize such a risk.

13) Obtaining a baseline recording from all intracranial electrodes used during the LTM procedure by:

- a) verifying electrode recording and artifacts;
- b) using appropriate recording and stimulus parameters;
- c) applying techniques that enhance or clarify the EEG abnormality (e.g., adding electrode derivations and montages);
- d) using sequential montage arrangement going from left to right, central to temporal, anterior to posterior, superior to inferior;
- e) determining adequacy of scalp site used for recording reference location;
- f) documenting and verifying electrode input descriptors, placement and equipment associations (which electrode name from what anatomical area, plugged into which jack input); and,
- g) following all recording standards set by ACNS Guidelines for LTM.

14) Identifying and eliminating or reducing artifacts contaminating the recording of EEG and video by:

- a) checking the quality of the signal;
- b) setting equipment gain factors and amplifier parameters appropriately;
- c) performing impedance checks periodically and when any suspicion of high impedance and adjusts appropriately;

- d) recognizing artifact as physiologic or non-physiologic;
- e) identifying source of artifact and corrects or eliminates;
- f) securing headbox/transmitter system to protect against disconnection during seizures or patient events;
- g) ensuring proper grounding of patient and equipment; and,
- h) recognizing artifacts related to networking and loss of connectivity.

15) Performing bedside testing of patients during and after seizures by:

- a) Obtaining baseline testing appropriate to patient's age and level of development;
- b) assessing patient's language function by having patient read standardized phrases or name pictures during ictal and postictal states and comparing results to baseline testing;
- c) giving patients simple and complex commands during LTM procedures; and,
- d) testing memory and cognitive function relative to LTM.

16) Acquiring and reviewing selected data to discuss with the clinical neurophysiologist by:

- a) reviewing complete data from monitoring period by some form of fast review method or reviews data extracted by a computerized automatic event detection system;
- b) extracting portions of electrographic data for inter-ictal (both wake and sleep) and ictal samples;
- c) identifying and accurately describing the chronology of clinical correlates during an event;
- d) selecting 2-3 minutes of baseline recording before and after an event;
- e) documenting seizure/event, clinical behavior, time, and date;
- f) documenting neuro-assessment completion and time;
- g) documenting LTM review on technical worksheet including:
 - (i) patient identification;
 - (ii) recording parameters and system integrity check;
 - (iii) electrode placement including additional electrodes, input descriptors;
 - (iv) diagram of implanted electrodes;
 - (v) patient room and equipment used;
 - (vi) any system malfunction and troubleshooting steps;
 - (vii) mapping parameters and findings;
 - (viii) medication dosages and when anticonvulsants were tapered off or any other changes; and,
 - (ix) clinical events, times, behavioral correlates, patient assessment;
- h) transferring data between local and network drives from acquisition to review station for data review and permanent storage;
- i) archiving selected portions, such as patient events, for permanent storage;
- j) preparing a master tape of video and electrographic data;
- k) printing out and labeling all events based on laboratory protocol;
- l) reviewing daily chart notes regarding patient; and,
- m) interviewing patient or relatives daily to determine if events occurred and any unusual clinical behavior to confirm sensitivity of event detection system.

17) Completing the LTM procedure by:

- a) disconnecting patient from monitoring equipment, removing scalp electrodes from patient, and cleaning scalp, noting and taking care of any skin breakdown;
- b) cleaning electrodes and patient equipment; and,
- c) replenishing and maintaining adequacy of supplies for the LTM procedure.

18) Participating in bedside or intraoperative localization of language and sensorimotor cortex:

- a) assisting the physician during motor mapping to identify specific areas of motor function;
- b) observing the patient carefully and documenting movement or sensation during cortical mapping; and,
- c) preparing the equipment for cortical mapping to include:
 - (i) accurately connecting appropriate cortical inputs for electrical stimulation;
 - (ii) preparing biphasic electrical stimulator for use, including verifying settings;
 - (iii) selecting and verifying current intensities for mapping;
 - (iv) documenting intensities used and results of stimulation;
 - (v) noting thresholds for after-discharges;

- (vi) calibrating EEG equipment prior to recording; and,
- (vii) selecting appropriate timebase, sensitivity and bandpass setting to record after-discharges.

19) Initiating cortical recording in the operating room {Electrocorticography (ECoG)} by:

- a) preparing patient for ECoG by explaining recording procedure and applying appropriate reference/ground electrodes;
- b) calibrating and setting up EEG recording equipment using appropriate filters and sensitivity settings;
- c) selecting montages based on electrodes applied to cortex by the neurosurgeon before and during resection;
- d) identifying and troubleshooting artifacts encountered during the recording;
- e) maintaining and ensuring completeness of supplies used for ECoG; and,
- f) documenting electrographic findings during the recording, completing paperwork for submission to the clinical neurophysiologist.

20) Performing the Wada Test by:

- a) preparing equipment and supplies needed for recording in the special procedure;
- b) applying electrodes using the International 10/20 System of electrode placement based on ACNS guidelines;
- c) recording a 10-minute baseline with appropriate montage and filter settings;
- d) making notations on the recording as to the time of the injection of medicine, behavioral correlates and any other changes observed during the procedure; and,
- e) completing all paperwork associated with the Wada testing procedure.

21) Performing home ambulatory 24-hour EEGs by:

- a) preparing equipment;
- b) preparing and educating the patient on procedure;
- c) applying electrodes using the appropriate application method (e.g., paste, collodion, electrode cap); and,
 - (i) explaining take-home diary, event button, and computer;
 - (ii) wrapping head or having patient bring hat, scarf for travel home; and,
 - (iii) explains safety precautions;
- d) completing the study by:
 - (i) removing electrodes and cleaning scalp;
 - (ii) correlating patient diary and verbal 24-hr history with acquired data;
 - (iii) identifying events detected and those signaled by patient;
 - (iv) identifying artifacts; and,
 - (v) printing events and transferring event data for review and interpretation by clinical neurophysiologist.

22) Performing continuous EEG (cEEG) by:

- a) preparing equipment for the cEEG environment;
- b) preparing and educating patient, ICU/staff and their family on procedure:
 - (i) applying electrodes with collodion technique;
 - (ii) explaining documentation needed;
 - (iii) explaining safety precautions; and,
 - (iv) ensuring that cEEG is recording and eliminating or monitoring artifact;
- c) discontinuing the cEEG:
 - (i) removing electrodes and cleans scalp;
 - (ii) correlating patient worksheet with acquired data;
 - (iii) identifying events detected and those signaled by patient/staff/family;
 - (iv) identifying artifacts; and
 - (v) printing events and transferring event data for review and interpretation by clinical neurophysiologist

23) Preparing SPECT Scan by:

- a) disconnecting equipment so patient can have the SPECT procedure; and,

- b) reconnecting EEG recording equipment after SPECT scan, ensuring the integrity of electrodes and system once patient is reconnected.

GROUP 6 (optional add-on): The following Graduate Competencies for performing Intraoperative Neurophysiological Monitoring (IONM) build on the Group I NDT Competencies. Both groups of competencies are required in neurodiagnostic technology (NDT) programs that choose to develop an IONM add-on.

a. IONM

Entry-level competency is evidenced by the graduate's knowledge and ability in the following areas:

1) Practicing proper operating room conduct by:

- a) following standard precautions and transmission-based precautions, observing hospital policies surrounding clothing, caps, shoe covers and masks;
- b) avoiding contamination of sterile drapes, personnel, instruments, etc. and having an understanding of the sterile field;
- c) passing sterile electrodes to the surgical personnel in an approved sterile manner;
- d) placing bloody or contaminated items in biohazard containers and sharps in a sharps container; and,
- e) following hazardous material management guidelines; and,
- f) complying with operating room protocols for emergency and disaster situations.

2) Providing a safe recording environment by:

- a) obtain sterile electrodes before procedure and clean or dispose of electrodes after each procedure;
- b) following and documenting operating room (OR) protocols for sedation;
- c) discussing the underlying disease and formulating a recording strategy based on the patient's needs, in conjunction with a supervisor;
- d) having all equipment checked for safety annually or more frequently as indicated by written policy; maintaining individual equipment logs (safety checks, break downs, repairs, etc.) as required;
- e) using general safety precautions in handling of sharps, arranging cables and equipment to prevent injury;
- f) always making sure a ground electrode is appropriately placed.

3) Preparing a basic data form that includes:

- a) the name of the surgical procedure that is being performed;
- b) results of relevant studies, i.e., in patient history; and
- c) communicating possible contra-indications to the monitoring surgical team.

4) Beginning the procedure before the patient enters the operating room and/or during intubation and prepping by:

- a) Collecting patient history information (from patient, surgeon, or patient's chart as appropriate) prior to induction of the patient;
- b) Establishing a monitoring plan based upon history and exam documentation, and recognizing the patient's conditions that affect monitoring;
- c) Following protocol based on surgical procedure and maintaining respect and patient confidentiality according to Health Information Portability and Accountability Act (HIPAA);
- d) Verifying patient name, birth date, type and level of procedure prior to induction of patient;
- e) discussing anesthetic recommendations for monitoring per established department protocols, in a definitive but cordial manner, with anesthesia staff (this should include a discussion of the effects different types of anesthetics have on the planned monitoring);
- f) referring potential conflict between the planned anesthesia and the monitoring to the appropriate personnel;
- g) documenting all communications related to these discussions;
- h) confirming with surgeon and appropriate personnel which structures are at risk and modalities to be monitored prior to surgery;
- i) confirming with the surgeon their understanding of what is involved with the surgery, relaying any changes as appropriate, and documenting conversation(s) prior to induction of the patient;
- j) explaining all IONM test procedures and explains electrode application if patient is awake and signing consent per hospital policy;

- k) collecting patient history information (from patient, physician, OR staff and patient's chart as appropriate) prior to induction of the patient;
 - l) setting up equipment and performing calibration appropriate for equipment type prior to induction of the patient;
 - m) testing equipment and checking integrity of electrodes by checking and documenting impedances;
 - n) arranging head box, cables and electrodes for minimization of artifacts, and to prevent electrodes from being dislodged, dried or contaminated with fluids;
 - o) applying electrodes and securing placement;
 - p) discussing the need for soft padding to be placed in the mouth to prevent injury from stimulation and reaching an agreement about who will be responsible for this (monitorist or anesthesiologist) per department protocols;
 - q) double checking bite block prior to obtaining baselines and intermittently throughout procedure as appropriate per established department protocols;
 - r) obtaining baseline recordings prior to induction/intubation per established department protocols, and then again after induction of anesthesia and prior to skin incision;
 - s) reporting baseline findings;
 - t) documenting vital signs present at time of baseline;
 - u) assuring there is reliable communication with the supervising neurophysiologist and when remote monitoring is used, connects online to remote monitoring work station and assures computer dialog with appropriate personnel.
- 5) Applying electrodes by following a method that includes:**
- a) cleaning and prepping patient's skin prior to electrode application;
 - b) applying electrodes (primary and backup) and securing placement, and cleaning or disposing properly after each use;
 - c) using appropriate electrodes based on stimulus or recording sites;
 - d) adjusting electrode placement for anatomical defects or anomalies, documenting changes as appropriate for the recording or stimulation of neurophysiological data; and,
 - e) applying electrodes with a method appropriate to type, site and purpose, and verifying electrode impedances within the range of normal.
- 6) Documenting and reporting during the procedure:**
- a) appropriate bite blocks are in place following positioning;
 - b) montage, filters, paper speed and sensitivity setting changes;
 - c) surgical maneuvers and events;
 - d) levels of inhaled anesthetics, infusion rates of IV anesthetics, dosage of other IV medications administered, and use of muscle relaxants;
 - e) blood pressure, temperature and other physiologic parameters as appropriate per department protocols;
 - f) communications with appropriate personnel;
 - g) changes in the monitored signals and communicates with the surgeon and supervising neurophysiologist regarding the changes, according to documented policy and procedure alarm criteria;
 - h) unexpected interruptions of monitoring for technical reasons (e.g., machine shutdown, anesthetic levels too high, continuous use of electrocautery, artifact from C-arm);
 - i) all changes noted in the records including information related to the cause (e.g., technical, anesthetic, physiological);
 - j) all warnings to attending surgeon, surgeon replies, and corrective action taken;
 - k) critical communications with anesthesia team or other OR personnel;
 - l) all waveform tracings (printed and/or electronically archived (if "waterfall" display is used, each waveform must be fully visible);
 - m) exact time, peak labels, latencies and amplitudes for all printed traces as dictated by department or service policies; and,
 - n) technical details of the monitoring according to department protocols;
 - o) input and assistance of others, per established department protocols
- 7) Obtaining an IONM recording that includes:**

- a) a pre-incision anesthetized baseline;
 - b) additional baselines as may be necessary related to positioning or preintubation;
 - c) continuous monitoring during the surgical procedure;
 - d) periodic checks of electrode impedance;
 - e) reliable interpretable waveforms which are relatively artifact free and exhibit good replication;
 - f) use of appropriate recording and stimulus parameters; and,
 - g) obligate EP waveforms displayed according to recommended standard or policy.
- 8) Identifying and eliminating/reducing artifacts contaminating waveforms by:**
- a) checking the quality of the raw signal regularly or whenever needed;
 - b) understanding the meaning and significance of artifact rejection;
 - c) understanding and enhancing the relationship of signal to noise ratio by various means including but not limited to increasing the number of sweeps and changing the repetition rate;
 - d) recognizing whether the artifact is physiologic or non-physiologic
 - e) identifying source of the artifact (e.g., poor electrode application, malfunctioning stimulator, positioning of cables) and correcting it accordingly;
 - f) calculating frequency in Hz of rhythmic artifacts and understanding the effects of aliasing;
 - g) properly grounding the patient and equipment; and,
 - h) identifying and documenting extraphysiological artifacts, e.g. recording of EMG activity during IONM procedure if required.
- 9) Demonstrating customization of the recording procedure by:**
- a) evaluating initial observed waveforms to assess any protocol modifications required;
 - b) using additional electrode derivations and other techniques as needed to enhance or clarify the waveforms as a result of changes occurring during the recording process;
 - c) selecting montages appropriate for abnormalities seen and/or expected;
 - d) selecting appropriate instrument settings; and,
 - e) applying additional electrodes to localize abnormal amplitude and frequency of activity.
- 10) Completing the procedure by:**
- a) discarding disposable supplies, especially sharps and contaminated items, in an approved manner;
 - b) cleaning and disinfecting equipment, cables;
 - c) checking patient for burns, skin breakdown under electrode site/tape, and documenting incidents according to hospital policy and procedures;
 - d) completing the detailed test data worksheet that may include, but is not limited to:
 - (i) montage
 - (ii) time and voltage calibration scales;
 - (iii) filter settings;
 - (iv) side stimulated;
 - (v) stimulus parameters type (e.g., polarity, rate, duration, delay, intensity);
 - (vi) number of trials averaged;
 - (vii) polarity convention;
 - (viii) other modality-specific relevant information such as hearing thresholds, limb length, and height;
 - (ix) sedation/anesthesia dosage; and,
 - (x) obligate peaks with latencies and amplitudes.
 - e) preparing hard copy of the waveforms if required by lab policy; and
 - f) storing information on electronic media according to department policy.
- 11) Describing:**
- a) functional anatomy and physiology as it pertains to the underlying disease process and surgical procedure being performed;
 - b) medication effects on the IONM background and waveforms;
 - c) medical terminology and appropriate abbreviations;
 - d) signs, symptoms, and IONM correlates for common medical and surgical disorders;

12) Discussing:

- a) the optimal anesthetics for the modalities being monitored and preferences to be communicated effectively to the anesthesiologist documenting all communications related to these discussions;
- b) the importance of effective communication among all involved personnel concerning what is involved in the surgery, what structures are at risk and documenting and appropriate communication with the supervising neurophysiologist;
- c) vital signs and other physiologic factors, and their potential effects upon the monitoring being performed;
- d) the international system of electrode measurement and placement, and can demonstrate proficiency in this skill;
- e) the value of preoperative (prior to day of surgery) testing EPs, EEG and EMG for these patients;
- f) surgical procedure being performed;
- g) critical periods during the surgery where monitoring is most crucial;
- h) structures at risk and times of greatest risk;
- i) unique spine instrumentation and the effect of their corrective force;
- j) impact of preoperative deficits and intraoperative injuries on post-operative outcomes;
- k) waveform changes generated by:
 - (i) ischemia;
 - (ii) changes in blood pressure;
 - (iii) oxygen saturation;
 - (iv) temperature, core and limb;
 - (v) artifacts; and,
 - (vi) anesthesia;
- l) the principles of modern anesthetic techniques, including how:
 - (i) specific anesthetic agents affect central and peripheral nerve functioning;
 - (ii) muscle relaxants change responses, and how to monitor the level of neuromuscular blockade using a "train of four" technique;
 - (iii) specific anesthetics change ongoing EEG;
 - (iv) specific anesthetics change the latencies and amplitudes of evoked potentials; and,
 - (v) the method of delivering anesthetics (inhalation, infusion, bolus injection, low flow inhalation) affects EEG and evoked potentials;
- m) inhaled anesthetic volatility and related Minimal Alveolar Concentration (MAC) values;
- n) effects of changes in concentration of volatile agents (MAC) on patient and on monitoring;
- o) interactions between nitrous oxide and potent volatile anesthetics;
- p) any unstable physiological factors such as changes in CO₂ and hematocrit;
- q) the operating room environment:
 - (i) operating room etiquette;
 - (ii) use of collodion, acetone or other flammable materials;
 - (iii) potentially biohazardous material; and,
 - (iv) sharp electrodes;
- r) electrical safety issues related to:
 - (i) types of recording and stimulating electrodes;
 - (ii) cautery units and return grounding pads;
 - (iii) Other instruments that are connected to the patient;
 - (iv) multiple grounds; and,
 - (v) use of new equipment in the OR (bio-med checks at individual hospitals);
- s) infection control and safety issues surrounding correct protocols for reusable electrode/probe sterilization requirements;
- t) effects of other equipment (blood warmers, microscopes, etc.), on the quality of the intraoperative recording;
- u) troubleshooting; and
- v) understands general roles and responsibilities appropriate to his/her credentials.

13) Describing the benefit of future ongoing professional development for continuing competence post-graduation through the:

- a) review of neurodiagnostic procedures with the interpreting physician on a regular basis; and

- b) acquisition of continuing education units (CEUs).
- 14) Recognizing that digital IONM systems have preset acquisition templates and therefore will have verified the integrity of the recording system by:**
 - a) verifying amplifier function;
 - b) verifying appropriate filter settings;
 - c) verifying sensitivity settings; and,
 - d) correcting or reporting malfunctions or deviations as appropriate.
- 15) Stating how waveforms are affected by:**
 - a) amplifier and preamplifier integrity; and,
 - b) amplifier gain/display gain.
- 16) Recognizing:**
 - a) normal, abnormal, and unobtainable waveforms as related to clinical symptoms and/or diagnosis;
 - b) variations of waveforms specific for each age range;
 - c) IONM patterns for levels of consciousness, and
 - d) subclinical seizure patterns.
- 17) Demonstrating the following core competencies of allied health professionals:**
 - a) patient care that is compassionate, appropriate, and effective for the treatment and promotion of health;
 - b) principles of professionalism as manifest through a commitment to carrying out professional responsibilities, adherence to ethical principles, and sensitivity to patients of diverse backgrounds;
 - c) interpersonal and communication skills that result in the effective exchange of information and collaboration with patients, their families, and other health professionals; and,
 - d) systems-based practice as manifest by actions that demonstrate an awareness of and responsiveness to the larger context and system of health care including relevant state and carrier regulations, medical regulatory terminology, malpractice risks, statutory scopes of practice, The Joint Commission requirements, and legal restrictions on health care practice.
- 18) Stating and following technical criteria by:**
 - a) recognizing, documenting and correcting all artifacts;
 - b) recommending criteria for assessing IONM abnormalities and maturation of components;
 - c) concerning the aspects, electrical hazards, and recording techniques unique to hostile environments (e.g., OR, interventional neuroradiology suites);
 - d) properly grounding the patient and equipment;
 - e) including IONM normative data and
 - f) including other knowledge as detailed in the ABRET NDT Technology Practice Analysis.
- 19) Applying the principles and concepts of NDT instrumentation to the recording by:**
 - a) signal averaging and noise reduction;
 - b) analog to digital conversion including amplitude resolution, sampling rate, analysis time, sampling interval (dwell time), and Nyquist frequency;
 - c) the function of differential amplifiers including input impedance, common mode rejection, polarity convention and gain;
 - d) effects of stimulus and recording parameters on IONM waveforms;
 - e) the meaning and significance of artifact rejection;
 - f) electrode impedance and its importance; and,
 - g) basic electricity and electronics concepts and electrical safety.
- 20) Obtaining a technically satisfactory IONM EEG recording by:**
 - a) recognizing and documenting all EEG patterns that may be seen during the monitoring, and be able to explain their relevance to the performance of IONM;
 - b) establishing a preoperative, pre-anesthetic baseline;
 - c) establishing a post-anesthetic baseline prior to incision and reestablishing that baseline if necessary due to anesthetic effects prior to clamping as per department protocols;

- d) documenting blood pressure at frequent intervals and whenever there is a significant event; and,
- e) documenting all stages of surgery.

21) Following technical criteria for:

- a) recording neonatal and pediatric IONM EEG;
- b) procedures associated with cardiovascular surgery; and,
- c) procedures associated with sonography.

22) Establishing electrocorticography (EcoG) and subdural/depth electrode placement/recording by

- a) understanding placement of electrodes and sterile method of transfer of connector cables from surgeon to scrub nurse or coordinator;
- b) connecting cables and creating or identifying montages to record field;
- c) adjusting sensitivity parameters appropriately;
- d) identifying and troubleshooting artifacts encountered during the recording;
- e) recognizing and describing EEG waveforms consistent with epileptogenic foci in surgical field;
- f) explaining cortical stimulation procedures;
- g) correlating epileptogenic foci with neuroanatomy and clinical behaviors; and,
- h) completing procedure/paperwork and following infection control standards for electrode connector cables and other IONM equipment.

23) Completing Wada test and other radiographic/EEG procedures by:

- a) preparing equipment and supplies needed for recording in the special procedures;
- b) applying electrodes using the International 10/20 System of electrode placement based on the ACNS guidelines;
- c) running a 10-minute baseline with appropriate montage and filter settings;
- d) understanding angiographic procedures prior to beginning Wada test;
- e) understanding need for prior placement of EEG scalp electrodes before procedure;
- f) understanding anesthetic injection and CNS reaction on EEG brainwaves;
- g) describing brainwave changes as neurologist or other qualified professional establishes clinical behaviors associated with memory, speech, and other neurological testing procedures;
- h) documenting clinical behaviors on EEG recording during Wada testing of left and right hemispheres;
- i) establishing baseline recordings post-Wada procedure; and,
- j) completing procedure/paperwork and removing electrodes.

24) Obtaining a technically satisfactory EP recording by:

- a) discussing anesthetic recommendations for monitoring per established department protocols, in a definitive but cordial manner, with anesthesia staff (This should include a discussion of the effects different types of anesthetics have on the planned monitoring.);
- b) documenting all communications related to these discussions;
- c) understanding anatomy of IONM systems and generators of IONM components;
- d) understanding IONM correlates of certain clinical conditions such as neurologic, orthopedic, neurosurgical, and audiological disorders;
- e) understanding pathologic and non-pathologic factors affecting IONMs;
- f) understanding the principles of stimulation and accurate placement of recording electrodes;
- g) ensuring that the averager and stimulators are correctly synchronized;
- h) establishing and documenting that stimulating parameters are within safe limits as per established department protocols;
- i) ensuring that all stimulators are correctly delivering expected stimuli to the selected side;
- j) choosing the appropriate stimulus rate and adjusting as needed to reduce time-locked artifacts;
- k) obtaining clearly resolved IONM waveforms and obligate components according to recommended standard or department policy;
- l) recording at least two replications demonstrating consistency of latency and amplitude measurements;
- m) recognizing whether the artifact is physiologic or non-physiologic;
- n) calculating frequency in Hz of rhythmic artifacts and understanding the effects of aliasing;
- o) enhancing the signal to noise ratio by increasing the number of sweeps;

- p) applies additional electrode derivations and other techniques as needed to enhance or clarify abnormalities;
- q) checks the quality of the raw signal regularly or whenever needed;
- r) establishing baseline values prior to induction of anesthesia and positioning of the patient, if appropriate (as in cases of unstable cervical spine) and according to department protocols;
- s) monitoring continuously throughout the procedure - documenting evoked potential tracings at frequent intervals as directed by policy and procedure manuals.

25) Differentiating artifacts from NDT waveforms by:

- a) recognizing possible artifactual waveforms;
- b) documenting (on the recording) patient movements;
- c) supplying/recording leads for eye potentials or other physiological potentials (e.g., respiration, EMG), and applying/recording leads for ECGs;
- d) replacing electrodes exhibiting questionable activity or contact; and,
- e) troubleshooting for possible electrical interference.

26) Recognizing that Evoked Potentials are not normally recording in the operating room and obtaining a technically adequate VEP if needed by:

- a) obtaining relevant ophthalmologic and neurologic history;
- b) using a montage that records responses from both hemispheres;
- c) assessing the patient's ERG; and,
- d) explaining the limitations of using flash and LED stimuli.

27) Recording technically adequate BAEP data by:

- a) documenting any existing hearing loss or condition of ear structures;
- b) obtaining relevant audiologic, neurologic, and/or neurosurgical history, hearing loss, ear infections, dizziness, or tinnitus;
- c) assessing the patient's ear canals;
- d) noting the results of prior hearing evaluations;
- e) using molded ear speakers or inserting transducers to avoid contamination of the surgical field;
- f) using waterproof adhesive tape and/or bone wax to protect the ear speaker and ear canal from blood or fluids;
- g) choosing the appropriate montage, timebase, number of stimuli, sensitivity and band pass settings per department protocols;
- h) choosing the appropriate click polarity, rate and intensity;
- i) establishing hearing thresholds;
- j) correlating elevations in thresholds with any existing hearing loss or conditions of ear structures;
- k) expressing click intensity measures in equivalent units of dBSL, dBHL, or dB SPL;
- l) using techniques to enhance wave I resolution such as an ear to ear montage derivation or using an ear canal electrode or increasing stimulus intensity;
- m) using alternate click polarity to minimize stimulus artifact, or rarefaction or condensation clicks to obtain the best response as appropriate;
- n) using an appropriate stimulus intensity per department protocols;
- o) using an appropriate stimulus rate to resolve the most important BAEP components and maintaining the same rate throughout;
- p) obtaining adequate resolution of obligate waves I, III, and V;
- q) measuring and calculating the absolute latencies, amplitudes, and interpeak intervals of obligate peaks at baseline and throughout monitoring and adjusting the baselines as necessary due to anesthetic and other physiologic changes;
- r) masking the contralateral ear with appropriate intensity, when applicable; and,
- s) continuously monitoring the ear ipsilateral to surgical intervention (contralateral ear monitoring is also appropriate for large posterior fossa tumors, or as a control).

28) Recording direct nerve action potentials from the 8th cranial nerve simultaneously with the BAEPs during certain posterior fossa procedures by:

- a) providing the surgeon with a sterile direct nerve electrode for placement on the exposed 8th nerve;

- b) using the same auditory clicks to stimulate the ipsilateral ear at the same intensity and stimulus rate as that used with the BAEPs;
- c) using a montage referencing the direct nerve electrode to the ipsilateral ear; and,
- d) selecting appropriate timebase and recording sensitivity to record those high amplitude responses according to department protocols.

29) Recording technically adequate SEP data by:

- a) Obtaining relevant neurologic, orthopedic, and/or neurosurgical history or any other relevant pathway specific information such as the presence of peripheral neuropathy;
- b) Selecting appropriate timebase, sensitivity, and bandpass settings;
- c) maintaining stimulating electrode impedance equal and below 5000 ohms to assure proper stimulation and to decrease stimulus artifact;
- d) selecting current of sufficient intensity and duration to elicit a motor twitch from the appropriate areas of stimulation;
- e) using a montage that records obligate peak responses from peripheral nerve, spinal cord, sub-cortical structures and the cerebral cortex as appropriate (for example, sub-cortical responses can be used for monitoring spinal cord function, but cortical responses would be required in monitoring an aneurysm clipping) as per department protocols;
- f) recording from electrodes overlying the scalp surface, peripheral sites and from electrodes placed in the spinous process or epidural spaces, as per department protocols;
- g) marking waveforms and calculating the absolute latencies, amplitudes and interpeak intervals at baseline and throughout the monitoring procedure as per department protocols;
- h) recording from additional electrode derivations in case of technical problems in order to allow continuous recording as per department protocols; and,
- i) delivering unilateral alternating stimulation of left and right-sided nerves or on special occasions from bilateral stimulation (e.g., infants) per established protocols.

30) Recording technically adequate MEP data by:

- a) obtaining relevant neurologic, orthopedic, and/or neurosurgical history or any other relevant pathway specific information such as the presence of myelopathy;
- b) selecting appropriate timebase, sensitivity, and bandpass settings;
- c) placing electrodes appropriately on the scalp and maintaining stimulating electrode impedance equal and below 5000 ohms to assure proper stimulation and to decrease stimulus artifact;
- d) selecting current of sufficient intensity and duration to elicit a compound muscle action potential from relevant muscle groups;
- e) adjusting stimulus parameters such as train, interstimulus interval, voltage and/or current to obtain best possible responses;
- f) using a montage that records responses from selected muscle groups appropriate for the operate levels per department policy;
- g) marking waveforms at baseline, and documenting latency and/or amplitude of response per department protocols; and,
- h) marking waveforms throughout the monitoring procedure per department protocols.

31) Assisting in the localization of "sensorimotor" cortex by:

- a) discussing anesthetic recommendations for monitoring per established department protocols, in a definitive but cordial manner, with anesthesia staff (This should include a discussion of the effects different types of anesthetics have on the planned monitoring.);
- b) documenting all communications related to these discussions;
- c) obtaining relevant patient history;
- d) obtaining a pre-incision baseline with surface electrodes to confirm function of the somatosensory pathway and approximate latency of the N20 peak;
- e) selecting appropriate timebase, sensitivity and band pass settings per department protocols;
- f) selecting the appropriate stimulation site (normally, contralateral median nerve);
- g) recording from electrodes placed by the surgeon;
- h) preparing stimulus site to reduce stimulating electrode impedance;
- i) monitoring sub-cortical peripheral nerve site to verify stimulus effect;

- j) using a referential montage that records direct cortical responses and produces a physiologic "phase reversal";
- k) obtaining adequate resolution of the obligate components;
- l) recording from multiple cortical sites in order to obtain adequate localization; and,
- m) printing out a hard copy of simultaneous or sequentially recorded SEPs for the purpose of studying the amplitude gradient and polarity of the responses in relation to the location of the gyri.

32) Obtaining a technically adequate EMG, Evoked EMG/CMAP and Peripheral NAP by:

- a) choosing the appropriate stimulator type (and recording electrode type) to be used in the sterile field if Evoked EMG/NAP responses will be utilized, based upon established department protocols:
 - (i) For direct peripheral nerve action potentials, this includes the use of a tripolar (+ - +) stimulating electrode, with a single ground between the tripolar stimulator and a (bipolar) recording electrode;
- b) correctly passing sterile stimulator (and reference electrode if needed) and/or recording electrodes onto field at the beginning of the procedure, and connecting it/them correctly to the monitoring equipment;
- c) choosing the appropriate muscles/nerves to be monitored based on the surgical procedure being performed per department protocols;
- d) securely applying recording electrodes that are below 5000 ohms and balanced to ensure proper recording of the muscle activity;
- e) choosing the appropriate stimulation parameters including intensity, duration, and frequency of stimulation delivery per department protocols;
- f) monitoring the ongoing EMG through a loud speaker that provides continuous auditory feedback to the surgical team per department protocols;
- g) recognizing appropriate alarm criterion and reporting and documenting alerts per department protocols;
- h) verifying the level of neuromuscular blockade through ""TOF"" monitoring throughout monitored portion of the procedure per department protocols;
- i) recognizing pedicle screw stimulation thresholds and reporting them per department protocols; and,
- j) ensuring the neuromuscular blockade is used in a limited manner consistent with policies and procedures.

33) Explaining how to obtain a technically adequate Motor Cranial Nerve recording by:

- a) applying needle, sticky pads or hook wire recording electrodes to the appropriate muscles to record spontaneous and evoked EMG responses from the specific nerves. Impedance and recording function must be tested prior to prepping and draping;
- b) ensuring the neuromuscular blockade is not employed during monitoring;
- c) monitoring the ongoing EMG through a loud speaker that provides continuous auditory feedback to the surgical team per department protocols;
- d) providing a sterile stimulating probe of monopolar or bipolar concentric type per department protocols, when needed;
- e) selecting appropriate current intensity and duration to produce a moderate muscle twitch of the muscles from the cranial nerve being stimulated being cognizant of patient safety issues, and following established department protocols; and,
- f) recording spontaneous free-running EMG and evoked CMAPs.